

University of Cantabria / University of Granada

Organizers:



REHABEND 2022

Euro-American Congress

CONSTRUCTION
PATHOLOGY,
REHABILITATION
TECHNOLOGY AND
HERITAGE MANAGEMENT

Granada (Spain) - September 13th-16th, 2022

Sponsor entities:



REHABEND 2022

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

(9th REHABEND Congress)

Granada (Spain), September 13th-16th, 2022

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Introduction.....	3
Previous Congresses.....	4
Sponsor & Collaborating Entities.....	5
International Scientific Committee.....	9
Topics.....	15
Abstracts of the Congress.....	17
Keynote Lectures.....	37
1.- Previous Studies.....	45
1.1.- Multidisciplinary studies (historical, archaeological, etc.).....	47
1.2.- Heritage and territory.....	68
1.3.- Urban regeneration.....	83
1.5.- Social participation processes and socio-cultural aspects in rehabilitation projects	93
1.6.- Construction pathology.....	96
1.7.- Diagnostic techniques and structural assessment.....	122
1.8.- Vulnerability studies and risk management.....	157
1.9.- Guides and regulations.....	172
2.- Project.....	177
2.1.- Theoretical criteria of the intervention project.....	179
2.2.- Traditional materials and construction methods.....	184
2.3.- Novelty products applicable and new technologies.....	200
2.4.- Sustainable design and energy efficiency.....	218
3.- Building Intervention.....	243
3.1.- Intervention plans.....	245
3.2.- Rehabilitation and durability.....	248
3.3.- Reinforcement technologies.....	260
3.4.- Restoration of artworks.....	270
3.5.- Conservation of industrial heritage.....	272
3.6.- Examples of intervention.....	275
4.- Maintenance.....	289
4.1.- Construction maintenance and infrastructures	291
4.2.- Preventive conservation of built heritage.....	300
5.- Diffusion and Promotion.....	311
5.1.- Heritage and cultural tourism.....	313
5.2.- Teaching and training.....	318
5.3.- New technologies applied to the heritage diffusion.....	319
5.4.- Accessibility to cultural heritage.....	328
5.5.- Built heritage management	329

The **Euro-American Congress REHABEND 2022 on Construction Pathology, Rehabilitation Technology and Heritage Management** was carried out in **Granada (Spain)**, in **September 2022**. The event was co-organized by seventeen organizations of **eight European and American countries**, and it was co-chaired by the **University of Cantabria**, through its Building Technology R&D Group (GTED-UC), and the **University of Granada**.

REHABEND 2022 **continued the series of the eight previous REHABEND international events**, which had been developed since **2006 in different Spanish cities**. In the **2020 edition held online**, more than **325 papers** were presented by professionals and researchers from **more than 35 countries**.

Construction Pathology, Rehabilitation Technology and Heritage Management currently have great importance for construction sector. This prompted the organizers to propose the **technical event on these topics in Granada**, which Alhambra fortress, the magnificent gardens of the Generalife and the residential district of the Albaycín, a rich repository of Moorish vernacular architecture, have been declared as UNESCO World Heritage Site. This event aimed to collect the **advances obtained in the last two years in the theoretical knowledge and practical realizations** carried out on the referred topics. The Congress met around **280 technical contributions** coming from professionals, academics and specialists.

Based on previous experiences, the Congress **was proposed once again in the Euro-American cultural space**. The **official languages** were **English, Italian, Portuguese and Spanish**. Organizers understand that technical articles and oral presentations, with the support of graphic material and schemes, may be understood by the people who take part in the congress, as it was evident in previous editions of REHABEND.

Under these premises and the successful previous editions, the Congress was sponsored by the **Government of Spain, the Government of Andalusia, the Provincial Government of Granada, the Municipality of Granada, the Council of the Alhambra and the Generalife, Granada Convention Bureau, Sacromonte Abbey Foundation, Tecnalia, Mapei, the University of Cantabria and the University of Granada**. In addition, several Universities, Technical and Professional Associations, Institutes, Foundations and Companies committed their collaboration in order to the success of this initiative.

REHABEND 2022 organizers would like to thank the multiple received supports: to the **Sponsor and Collaborating Entities**; to the **Scientific Committee Members** for their hard work in the revision of the different technical contributions, ensuring the required level of quality of an international event; to the **Keynote Speakers**; to the different **Speakers** for their relevant contributions and, in general, to the **people who attended the congress** for the confidence shown in the event. Sincerely, many thanks to all.



Dr. Ignacio Lombillo

Chairman of the REHABEND 2022 Congress
Associate Professor
University of Cantabria



Dr. María Paz Sáez

Chairman of the REHABEND 2022 Congress
Associate Professor
University of Granada

The University of Cantabria, through its Building Technology R&D Group (GTED-UC), was the promoter of the REHABEND Congresses on Construction Pathology, Rehabilitation Technology and Heritage Management.

The 1st REHABEND Congress was set in motion in Santander in November 2006. It became established in the 2nd (Santander, 2007), 3rd (Valencia, 2008), 4th (Bilbao, 2009), 5th (Santander, 2014), 6th (Burgos, 2016) and 7th Congress (Caceres, 2018), all of them carried out in Spanish cities. The 2020 edition was to be held in person in Granada, Spain, in March 2020, but due to the global health emergency resulting from Covid-19, it had to be held online in September 2020.

The ability to convene of the eight performed editions was prominent, gathering an appreciable number of experts in the topics of the Congress. As a reference, in the 8th edition (REHABEND 2020) took part more than 325 speakers from more than 35 countries from all over the world.

The 3rd edition of the Congress (REHABEND 2008) was organized together with the Construction Technologic Institute of the Valencian Autonomous Community (AIDICO), and the 4th and 5th editions (REHABEND 2009 and 2014), in addition to AIDICO, the Congresses were co-organized with TECNALIA Research&Innovation. Since the 6th edition (REHABEND 2016) the congress has been co-organized by several entities from different Euro-American countries.

The covers and ISBN of the books of papers corresponding to the previous congresses are attached below. The ISSN of the series of REHABEND books is 2386-8198. In addition, since REHABEND 2014, the papers presented at the congress have been indexed in scopus.



REHABEND 2006
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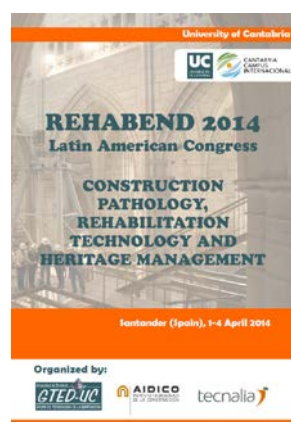
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REHABEND 2018
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The Collaborating Entities have been presented grouped in countries, following an alphabetical order. As Collaborating Entities have been considered to all that have contributed at least with two accepted articles in the Congress, or that some of its members formed part of the International Scientific Committee of the Congress / keynote speakers. Finally, in each country, the Collaborating Entities have been ordered according to the number of accepted articles.

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1.- PREVIOUS STUDIES	1.1.- Multidisciplinary studies (historical, archaeological, etc.). 1.2.- Heritage and territory. 1.3.- Urban regeneration. 1.4.- Economical and financial policies. 1.5.- Social participation processes and socio-cultural aspects in rehabilitation projects. 1.6.- Construction pathology. 1.7.- Diagnostic techniques and structural assessment. 1.8.- Vulnerability studies and risk management. 1.9.- Guides and regulations.
2.- PROJECT	2.1.- Theoretical criteria of the intervention project. 2.2.- Traditional materials and construction methods. 2.3.- Novelty products applicable and new technologies. 2.4.- Sustainable design and energy efficiency.
3.- BUILDING INTERVENTION	3.1.- Intervention plans. 3.2.- Rehabilitation and durability. 3.3.- Reinforcement technologies. 3.4.- Restoration of artworks. 3.5.- Conservation of industrial heritage. 3.6.- Examples of intervention.
4.- MAINTENANCE	4.1.- Construction maintenance and infrastructures. 4.2.- Preventive conservation of built heritage.
5.- DIFFUSION AND PROMOTION	5.1.- Heritage and cultural tourism. 5.2.- Teaching and training. 5.3.- New technologies applied to the heritage diffusion. 5.4.- Accessibility to cultural heritage. 5.5.- Built heritage management.

ABSTRACTS OF **THE CONGRESS**

KEYNOTE LECTURES

1	THE USE OF TITANIUM IN CONSERVATION AND SEISMIC REINFORCEMENT OF MASONRY STRUCTURES <i>Corradi, Marco; Adkins, Jill</i>	39
2	STRENGTHENING OF MASONRY STRUCTURES WITH INORGANIC MATRIX COMPOSITES (IMCS) <i>Aiello, Maria Antonietta</i>	40
3	PROGRESSIVE COLLAPSE AND ROBUSTNESS OF BUILDINGS AND BRIDGES <i>Adam, José M; Buitrago, Manuel; Makoond, Nirvan</i>	41
5	ARCHITECTURE OF MANY EPOCHS: THE SACROMONTE ABBEY IN GRANADA <i>Martín Muñoz, Antonio</i>	42
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>	43

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>	47
16	DEVELOPMENT OF THE CONSTRUCTION SYSTEM OF THE SOUTHERN GOTHIC CATHEDRAL PROFILE <i>Lluís-Teruel, Cinta; Lluís i Ginovart, Josep</i>	48
20	THE HOROLOGION OF ANDRONIKOS OF KYRROS IN ATHENS, GREECE: CULTURAL HERITAGE ISSUES AND HISTORICAL EVIDENCE <i>Panou, Evangelia; Alexopoulou, Athina Georgia</i>	49
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>	50
34	THE CITY OF SUCEAVA - ASPECTS OF URBAN DEVELOPMENT <i>Cioban, Andreea G.; Agachi, Mihaela I. M.</i>	51
65	THE HISTORIC ARCHITECTURAL COMPLEX OF MANGUINHOS, RIO DE JANEIRO, RJ, BRAZIL <i>Oliveira, Benedito Tadeu de</i>	52
95	HISTORICAL ARCHIVE OF THE CITY OF LOJA, ECUADOR <i>Delgado Cruz, María José; Sanz González, Sofía</i>	53
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>	54
150	BLURRED FAÇADE AS THRESHOLD ARCHITECTURE <i>Yapicioglu, Balkiz; Cazacova, Liudmila</i>	55
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>	56
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>	57
290	THE FIRST APPROACH TO TRENCADIS OF GAUDI: METHODS OF GEOMETRIC ANALYSIS <i>Asadova, Zahra; Navarro, Isidro; Santana, Galdric</i>	58
294	SANTA COLOMA D'ANDORRA - THE CONCEPTION OF A CHURCH BEFORE THE 11TH CENTURY. <i>Pedragosa Batllori, Gemma</i>	59
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>	60
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>	61
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>	62
348	ON ARCHITECTURE FROM THE SECOND HALF OF THE XX CENTURY IN POLAND <i>Zychowska, Maria J.; Bialkiewicz, Andrzej</i>	63
366	DETERIORATIONS AND RECOVERY PROJECTS IN THE FORTIFICATIONS OF THE CARIBBEAN COAST OF PANAMA, PORTOBELO AND SAN LORENZO. <i>Durán, Félix; García, Elizabeth</i>	64
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>	65
372	CONSERVATION AS A DESIGN OPPORTUNITY. PROTECTION SYSTEMS IN THE ARCHAEOLOGICAL FIELD <i>Cadoni, Stefano</i>	66

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>	67
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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>	68
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>	69
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>	70
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>	71
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; Andrucci, Giovanna</i>	72
126	CHARACTERIZATION OF NATIVE SHUAR ARCHITECTURE: ARCHITECTURAL TYPES, REPRESENTATIVE ELEMENTS AND CONSTRUCTION SYSTEMS <i>Soto Toledo, Katherine Haydee; Rodríguez Torres, María José</i>	73
127	19TH CENTURY MERSIN COMMERCIAL BUILDINGS, PRESENT CONDITIONS, AND PROBLEMS OF CONSERVATION <i>Darendeli, Tuğçe; Umar, Nur</i>	74
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>	75
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>	76
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>	77
275	FENCE WALLS IN THE BAIXO TÂMEGA VALLEY <i>Pinto, Jorge; Reis, Cristina; Bento, Ricardo; Bentes, Isabel; Pereira, Sandra</i>	78
284	EUROPEAN SMART VILLAGES: STATE OF THE ART AND POSSIBLE DEVELOPMENT SCENARIOS <i>D'Andria, Emanuela; Fiore, Pierfrancesco; Falce, Carmelo</i>	79
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>	80
316	EARLY REPUBLIC PERIOD MALATYA STATION BUILDINGS <i>Sarı, Fatma Zehra; Umar, Nur</i>	81
394	THE RECONSTRUCTION OF ZIKUÑAGA CHAPEL OF HERNANI: BUILT HERITAGE LOST AND FOUND <i>Uranga, Eneko J.; Arraztio, Xabier; Uranga, Juan José</i>	82

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>	83
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>	84
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>	85
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>	86

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>	87
106	GLOBAL ARCHITECTURE: REHABILITATION AND REGENERATION <i>Vitrano, Rosa Maria</i>	88
299	MANAGEMENT MODELS FOR ENERGY REGENERATION IN URBAN AND RURAL AREAS OF NAVARRA <i>Izcue, Isabel; García Madruga, Carolina</i>	89
369	THE HOUSING HARDSHIP IN ROME. PUBLIC RESIDENTIAL BUILDING VS SOCIAL HOUSING? <i>Crupi, Francesco</i>	90
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>	91
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>	92

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>	93
169	THE SOCIAL PARTICIPATION IN THE CASE OF MANGUINHOS HISTORIC ARCHITECTURAL NUCLEUS (NAHM) <i>Almeida, Roberta dos Santos; Pinheiro, Marcos José de Araújo</i>	94
327	CITIZEN PARTICIPATION FOR HERITAGE INTERVENTION. AN EXPERIENCE IN LUCENA (CORDOBA) <i>Navas-Carrillo, Daniel; Mosquera-Adell, Eduardo; Pérez-Cano, Teresa</i>	95

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>	96
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>	97
9	PATHOLOGICAL MANIFESTATIONS IN SANDWICH VERTICAL PANELS: CASE STUDY <i>Lordsleem Jr., Alberto Casado; Lira, Virginia Queiroz</i>	98
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>	99
30	PARAMETERISATION OF THE DEGRADATION PROCESSES IN COATED FAÇADES WITH ONE COAT MORTAR RENDERS <i>Carretero-Ayuso, Manuel J.; Pinheiro-Alves, Mª Teresa; Sáez-Pérez, Mª Paz</i>	100
53	THE USE OF MACROPOROUS MORTAR IN THE REHABILITATION OF HANDMADE BRICK WALLS WITH RISING DAMP <i>Camino-Olea, Mª Soledad; Llorente-Álvarez, Alfredo; Cabeza-Prieto, Alejandro; Martín-Aldudo, Ernesto; Mª Paz Sáez-Pérez; Rodríguez-Esteban, Mª Ascensión</i>	101
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>	102
62	CONSTRUCTIVE STUDY OF THE SHIPWRECKED HOUSE IN THE PORT OF BILBAO <i>Marcos, Ignacio; Díez, Jesús; Piñero, Ignacio; Egiluz, Ziortza</i>	103
84	MONTEVIDEO MUNICIPAL OSSUARY. INTEGRAL STUDY AND MANAGEMENT PLAN <i>Fontana, Juan José; Gambini, Jorge; Méndez, Mary; Tomeo, Fernando; Romay, Carola</i>	104
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>	105
128	ANALYSIS OF DOCUMENTAL AND EXECUTIVE PROCESSES OF CONSERVATION OF BUILDINGS TAKEN AS HISTORICAL HERITAGE <i>Andrade, Ana Paula Cintra</i>	106

132	STUDY OF THE HERITAGE BUILDING COMPLEX OF THE NATIONAL MUSEUM OF COSTA RICA FROM A HISTORICAL, ARCHITECTURAL AND PATHOLOGICAL PERSPECTIVE	
	<i>Porrás-Alfaro, David; García-Baltodano, Kenia; Méndez-Álvarez, Dawa</i>	107
162	FACADE DAMAGE MAPS: A LITERATURE REVIEW	
	<i>Lopes, Melissa L. F.; Silva, Maykon V.; Bauer, Elton</i>	108
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>	109
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>	110
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>	111
203	THERMAL ANALYSIS OF SODIUM SULFATE CRYSTALLIZATION WITHIN POROUS BUILDING MATERIALS	
	<i>Bednarska, Dalia; Koniorczyk, Marcin</i>	112
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>	113
216	BUILDINGS INVESTIGATION OF DEGRADATION VARIABILITY IN BRASÍLIA-BRAZIL CITY	
	<i>Rodrigues Neto, Eduardo; Bauer, Elton</i>	114
226	THE WOOD MOISTURE FACTOR ON THE BIOLOGICAL DETERIORATION OF WOODEN STRUCTURES	
	<i>Lima, Daniel F.; Tenório, Marina; Branco, Jorge M.; Nunes, Lina</i>	115
241	DEEP LEARNING FOR DETECTING CRACKS IN PAINTED BUILDING FAÇADES	
	<i>Pereira, Sandra; Pires, João; Silva, João; Ferreira, Tomás; Neto, Alexandre; Cunha, António</i>	116
265	IDENTIFICATION OF HERITAGE STONE BUILDING DEGRADATION PATTERNS BASED ON DIGITAL PHOTOGRAMMETRY DATA	
	<i>Jalón, María L.; Chiachio, Juan; Gil-Martín, Luisa María; Hernández-Montes, Enrique</i>	117
266	CASE OF STUDY: DIAGNOSIS OF 100 YEARS OLD ABANDONED MILL	
	<i>Cetrangolo, Gonzalo; Romay, Carola; Mussio, Gianella; Spalvier, Agustin</i>	118
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>	119
324	PATOLOGY AND NUMERICAL MODEL OF THE TEMPLE OF SAN FRANCISCO TZINTZUNTZAN	
	<i>Márquez, Alberto; Olmos, Bertha; Jara, José Manuel; Martínez, Guillermo</i>	120
349	CONSOLIDATION OF A POROUS SANDSTONE USED IN ANCIENT CONSTRUCTIONS	
	<i>Lamas, Pedro; Pinho, Fernando</i>	121

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>	122
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>	123
44	NUMERICAL APPROCHES FOR SOIL-STRUCTURE INTERACTION IN A HISTORICAL INDUSTRIAL MASONRY BUILDING	
	<i>Longarini, Nicola; Crespi, Pietro; Zucca, Marco; Scamardo, Manuela</i>	124
46	ENGINEERING SKILLS AIDED BY THERMOGRAPHY AND BIM	
	<i>Ribeiro Antunes, Maria Luisa; Cabaleiro Cortizo, Eduardo; Magalhães Lenz César Júnior, Kleos</i>	125
60	SEISMIC VULNERABILITY AND RETROFITTING OF A HISTORICAL MASONRY BUILDING	
	<i>Scamardo, Manuela; Crespi, Pietro; Longarini, Nicola; Zucca, Marco</i>	126

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>	127
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>	128
90	A NEW CLASSIFICATION 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>	129
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>	130
158	FUNICULAR ANALYSIS OF MASONRY VAULTS UNDER GENERAL LOADING CONDITIONS THROUGH A CONSTRAINED FORCE DENSITY METHOD <i>Bruggi, Matteo; Taliercio, Alberto</i>	131
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>	132
173	SHAKING TABLE TEST DESIGN OF A TYPICAL CHURCH OF MORELOS STATE <i>Chávez, Marcos M.; Durán, Daniel</i>	133
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>	134
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>	135
237	THE ROLE OF THE EARTHQUAKE VERTICAL COMPONENT ON THE SEISMIC BEHAVIOUR OF MASONRY WALLS <i>Camata, Guido; Di Primio, Alice; Sepe, Vincenzo</i>	136
243	EXPERIMENTAL STUDY ON CALIBRATION FACTOR OF FLAT - JACKS <i>Blanco, Haydee; Boffill, Yosbel; Lombillo, Ignacio; Renedo, Carlos; Sosa, Israel; Carrasco, Cesar</i>	137
256	INSPECTION AND STRUCTURAL EVALUATION OF A MASONRY ARCH FOOTBRIDGE, BAIRRO DOS ANJOS BRIDGE - LEIRIA <i>Christo, Guilherme; Veludo, João; Gaspar, Florindo</i>	138
258	INVESTIGATION OF MASONRY DEFORMABILITY THROUGH FLAT-JACK TESTING: A NUMERICAL STUDY <i>Alecci, Valerio; De Stefano, Mario; Marra, Antonino Maria; Stipo, Gianfranco</i>	139
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>	140
268	METODOLOGY 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>	141
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>	142
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>	143
302	SEISMIC VULNERABILITY ASSESSMENT AND RETROFIT MEASURES FOR MEDIEVAL STONE MASONRY MINARETS IN EGYPT <i>Hamdy, Gehan</i>	144
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>	145
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>	146

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>	147
326	HOMOGENIZED NONLINEAR PROPERTIES OF URM STRUCTURES <i>Valadao, Ryan Manuel; Pantazopoulou, S.J.</i>	148
355	NON-DESTRUCTIVE TECHNIQUES USED IN THE DIAGNOSIS OF THE MANSARD ROOF STRUCTURE OF THE URIARTE DE HEBER PALACE <i>Torán, Susana</i>	149
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>	150
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>	151
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>	152
387	FROM PRELIMINARY STUDIES TO RESTAURO OF CASA BATLLÓ BY ANTONI GAUDÍ <i>Olona, Joan; Bosch, Mireia; Villanueva, Xavier; Villanueva, Ignasi</i>	153
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>	154
399	PETROGRAPHIC STUDY OF THE MURAL PAINTING COATINGS OF THE SAN JORGE CHURCH (LEDANTES, CANTABRIA) <i>Sánchez Carro, Miguel A.; Quevedo González, Lydia</i>	155
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>	156

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>	157
42	A CRITICAL ROUTE FOR DOCUMENTING THE SEISMIC VULNERABILITY ON MEXICAN HISTORICAL CITIES <i>Ramírez Eudave, Rafael; Ferreira, Tiago Miguel; Romeu, Vicente</i>	158
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>	159
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>	160
82	EMERGENCY INTERVENTIONS AND COST ASSESSMENT FOR SEISMIC DAMAGES ON CULTURAL HERITAGE <i>Ferrari, Lia</i>	161
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>	162
130	SEISMIC PERFORMANCE OF TYPICAL HYBRID BUILDINGS IN THE URBAN CENTRE OF BARCELONA <i>Dimovska, Sara; Saloustros, Savvas; Pelà, Luca; Roca, Pere</i>	163
134	THE “ALQUERÍA DE FALCÓ” (VALENCIA): SEISMIC VULNERABILITY ASSESSMENT AND INTERVENTION STRATEGIES <i>Basset-Salom, Luisa; Guardiola-Villora, Arianna</i>	164
213	RISK MANAGEMENT IN THE CONTEXT OF INTERVENTION WORKS IN HISTORIC BUILDINGS <i>Coelho, Carla; Sá, Bruno; Carcereri, Maria Luiza; Zouain, Rosana</i>	165
245	CULTURAL HERITAGE BUILDINGS AND RELEVANT USES: SEISMIC RISK ASSESSMENT IN FLORENCE <i>Cardinali, Vieri; Cristofaro, Maria Teresa; De Stefano, Mario; Tanganelli, Marco</i>	166

278	PASSIVE ENERGY DEVICES FOR RETROFITTING FIRST SOFT-STORY BUILDINGS IN MEXICO <i>García, Carlos; Jara, José; Olmos, Bertha; Martínez, Guillermo</i>	167
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>	168
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>	169
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; Julver Pino</i>	170
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>	171

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>	172
184	PRESERVO - COMPLEX OF FIOCRUZ COLLECTIONS: PATH OF A CULTURAL HERITAGE PRESERVATION STRATEGY <i>Pinheiro, Marcos José de Araújo; Coelho, Carla</i>	173
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>	174
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>	175

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>	179
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>	180
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>	181
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>	182
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>	183

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>	184
43	DECIMONONIC WOODEN BRIDGES IN THE CENTRAL REGION OF THE COLOMBIAN ANDES <i>Galindo-Díaz, Jorge; Escobar-García, Diego; Flórez, Gilberto</i>	185
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>	186
105	USE OF CHALCEDONITE POWDER AS A SUPPLEMENTARY MATERIAL IN LIME MORTARS <i>Vyšvařil, Martin; Krebs, Martin; Bayer, Patrik</i>	187
112	USE OF FINE-GROUND LAVA SAND AS A POZZOLANIC ADDITIVE IN AERIAL LIME-BASED MORTARS <i>Žižlavský, Tomáš; Vyšvařil, Martin</i>	188
123	CONSTRUCTIVE TYPOLOGIES ON PREHISPANIC STONE WALLS IN THE REGION OF PUNO, PERU <i>Tarque, Nicola; Lipa Cusi, Leonel</i>	189
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>	190
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>	191
193	STRUCTURAL ANALYSIS FOR CONSTRUCTIVE HYPOTHESIS OF THE ANNULAR VAULT OF CARLOS V PALACE IN GRANADA (SPAIN) <i>Puertas, Esther; Gallego, Rafael</i>	192
224	THE "ORO NERO" IN THE ARCHITECTURE OF THE THIRTIES IN SOUTHEASTERN SICILY. MEANINGS AND IMITATIONS OF A LOCAL MATERIAL <i>Cavallo, Alessandro</i>	193
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>	194
337	REHABILITATION OF EARTHEN ARCHITECTURE, FROM COURTYARD HOUSES TO BRAZILIAN HOUSES IN THE CENTER OF PORTUGAL <i>Tavares, Alice; Costa, Aníbal</i>	195
353	METHODOLOGY OF EVALUATION OF TECHNOLOGIES. PROPOSAL APPLIED TO BUILDING INTERVENTIONS <i>Bozzo, Laura</i>	196

362	PORTUGUESE VERNACULAR CONSTRUCTION AND ITS SUSTAINABLE REHABILITATION CHALLENGES: THE SCHIST VILLAGES, LOUSÃ	197
	<i>Mouraz, Catarina P.; Silva, J. Mendes; Ferreira, Tiago Miguel</i>	
363	INFLUENCE OF REGIONAL GEOLOGICAL CHARACTERISTICS ON PORTUGUESE VERNACULAR CONSTRUCTION: CASE STUDIES	198
	<i>Silva, J. Mendes; Mouraz, Catarina; Ferreira, Tiago Miguel; Catarino, Lúcia; Almeida, Vanessa</i>	
371	EARTH BUILDINGS IN CRETE: BUILDING CONSTRUCTION KNOWLEDGE THROUGH THE DOCUMENTATION AND PRESERVATION OF EARTHEN ARCHITECTURAL HERITAGE	199
	<i>Kada, Dimitra; Mandalaki, Maria</i>	

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	200
	<i>Garcia, Ramiro; Reyes, Encarnación; Villanueva, Paula; De La Rubia, Miguel Angel; Fernández, Jaime; Moragues, Amparo</i>	
70	SIDERURGICAL MORTARS IN SPAIN: REHABILITATION OPPORTUNITIES AND AN OVERVIEW OF PROGRESS	201
	<i>Sanamaría, Amaia; Esteban, Alberto; Skaf, Marta; García-Cortés, Verónica; González, Javier Jesús</i>	
71	EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF MICROCEMENT-BASED GROUTS	202
	<i>Hortigon, Beatriz; Ancio, Fernando; Espinal, Jose Santiago; Rodriguez-Mayorga, Esperanza</i>	
72	LIGHTWEIGHT CEMENT COBBLE MADE WITH RECYCLED ROOF WASTES	203
	<i>Alonso Díez, Álvaro; Arroyo Sanz, Raquel; Alameda Cuenca-Romero, Lourdes; Gutiérrez-González, Sara; Calderón Carpintero, Verónica; Rodríguez Sáiz, Ángel</i>	
91	CLIMATIC PERFORMANCE INDICATOR BASED ON FUZZY LOGIC: APPLICABILITY TO THE ARCHITECTURE, ENGINEERING AND CONSTRUCTION SECTOR	204
	<i>Prieto, Andrés J.; Carpio, Manuel</i>	
125	FEASIBILITY OF DEFECT DETECTION IN CONCRETE CYLINDERS BY MEANS OF MUON SCATTERING RADIOGRAPHY (MSR)	205
	<i>Orio, Aitor; Martínez, Pablo; Díez, Carlos; Gómez, Pablo</i>	
157	THE BUILDING STOCK REHABILITATION: THE CONTRIBUTION OF VERTICAL GREENERY SYSTEMS (VGS)	206
	<i>Lo Faro, Alessandro; Moschella, Angela; Lombardo, Grazia; Salemi, Angelo; Sciuto, Gaetano; Nocera, Francesco; Costanzo, Vincenzo</i>	
166	PRELIMINARY STUDIES TO IDENTIFY SUITABLE DEMONSTRATORS FOR RADON REMOVAL WITH INNOVATIVE PAVEMENTS	207
	<i>Alonso, Carmen; Frutos, Borja; Manglano, Libertad; Castaño, Enrique; Sicilia, Isabel; Baño, Antonio; Martín-Consuegra, Fernando</i>	
239	EXPERIMENTATION OF NEW PRODUCTS AND SOLUTIONS AT FULL SCALE IN KUBIK. ITS EVOLUTION AND TRANSFORMATION IN 10 YEARS OF OPERATION	208
	<i>San Mateos Carretón, Rosa; Garay-Martinez, Roberto; Egiluz, Ziortza</i>	
247	REUSE OF RESIDUAL DIATOMACEOUS EARTH FOR THE PRODUCTION OF GEOPOLYMERS – A REVIEW	209
	<i>Magalhães, Leandro; Ferreira, Débora; Luso, Eduarda; Lima, Óscar</i>	
252	NUMERICAL EVALUATION OF THE STRUCTURAL CONTRIBUTION OF STRENGTHENING FOR TENSION PERPENDICULAR TO THE GRAIN AND SHEAR IN REINFORCED CONCRETE JOINTS FOR TIMBER FRAMES	210
	<i>Ribeiro, Alécia; Negrão, João; Dias, Alfredo</i>	
257	GRAPHENE OXIDE AS ADDITIVE FOR INCREASING THE STRENGTH AND DURABILITY PERFORMANCE OF EXISTING CONCRETE STRUCTURES	211
	<i>Longarini, Nicola; Cabras Luigi</i>	
260	USE OF REMOTELY PILOTED AIRCRAFT (DRONES) FOR THE INSPECTION OF ARCHITECTURAL HERITAGE AND ANCIENT STRUCTURES	212
	<i>Rodríguez Elizalde, Rubén</i>	
269	USE OF BIOCEMENTATION FOR SEALING STONE JOINTS	213
	<i>Cardoso, Rafaela; Barroso, Ana Catarina; Borges, Inês; Fernández Rodríguez, Román; Flores-Colen, Inês</i>	
277	APPLICATION OF NANOTECHNOLOGY TO OBTAIN SUSTAINABLE CEMENT-BASED MATERIALS WITH HIGH DURABILITY	214
	<i>Ruiz, Alberto; De la Rubia, Miguel Ángel; Reyes, Encarnación; Moragues, Amparo</i>	
306	POSSIBILITIES OF USING CALCIUM HYDROXIDE-BASED NANOMATERIALS IN THE CARE OF HISTORICAL SURFACES	215
	<i>Kroftova, Klara; Witzany, Jiri; Zigler, Radek; Cejka, Tomas</i>	

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>	216
383	HEAT AND PRESSURE DEVELOPMENTS IN CHEMICAL DEMOLITION AGENTS	
	<i>Atteyeh, S. Natanzi; Laefer, Debra F.</i>	217

2.4.- Sustainable design and energy efficiency.

6	ASSESSING THE THERMAL ENVIRONMENT OF SOUTH INDIAN HISTORIC TEMPLE TOWNS BY USING CFD MODELLING	
	<i>Kiruthiga, K.; Thirumaran, K.</i>	218
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>	219
38	PROPOSITION FOR HEALING MECHANICAL VENTILATION SYSTEMS WITH RESONANT KEPPE MOTOR TECHNOLOGY: ANALYSIS IN A BRAZILIAN PRIVATE SCHOOL	
	<i>Koivukangas, Sari Hannele</i>	220
52	BIOCLIMATIC STUDY OF THE ARCHITECTURE IN THE EASTERN ALMERÍA	
	<i>García-Ruiz, Luisa-María; García-Ruiz, Almudena; Sáez-Pérez, María-Paz</i>	221
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>	222
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>	223
108	POLYFUNCTIONALITY IN UNIQUE ARCHITECTURES: KEY TO PERMANENCE AND KEY TO SUSTAINABILITY	
	<i>Agudo Martínez, Andrés; Vázquez Sánchez, Gloria; Lucas Ruiz, Rafael</i>	224
114	SEISMIC AND ENERGY RETROFIT OF HISTORIC BUILDINGS: A MODEL TO SUPPORT INTEGRATED DESIGN	
	<i>Roncaccia, Elisa; Losco, Giuseppe</i>	225
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 y Galán-Marín, Carmen</i>	226
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>	227
153	INSTALLATION OF DIFFERENT PHOTOVOLTAIC SYSTEMS IN A BUILDING FOR EDUCATIONAL USE	
	<i>Zurro, Belén; González, Sara; González, José Manuel; Rodríguez, Ángel</i>	228
154	CHECKING THE TECHNICAL SUITABILITY OF THE VENTILATED FAÇADE SOLUTION	
	<i>Zurro, Belén; González, Sara; González, José Manuel; Rodríguez, Ángel</i>	229
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>	230
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>	231
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>	232
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>	233
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>	234

191	INTEGRATED REDEVELOPMENT OF INDUSTRIAL BUILDINGS: A CASE STUDY IN CENTRAL ITALY <i>Banti, Neri; Di Naso, Vincenzo; Ciacchi, Cecilia; Bazzocchi, Frida</i>	235
212	ENERGY EFFICIENCY AND PRESERVATION OF DIFFUSE HISTORIC BUILDINGS: OPPORTUNITIES AND OPEN QUESTIONS <i>Pizzoli, Rolando; Cardani, Giuliana; Bassani, Paola</i>	236
323	ENERGY EFFICIENCY AND COST OF ENERGY (POSSIBLE SCENARIOS) <i>Balbás, Francisco Javier; Aranda, José Ramón; Carrasco, César; Ceña, Alberto; García, Javier</i>	237
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>	238
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>	239
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>	240
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>	241

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>	245
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>	246
360	CHALLENGES OF THE PRESERVATION OF HERITAGE BUILT IN STONE AND ARMED CONCRETE ON THE ISLAND OF MOZAMBIQUE <i>Alcolete, Isekiel; Silva, J. Mendes; Lage, Luís; Mouraz, Catarina</i>	247

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>	248
137	CONCRETE CRACK REPAIR WITH EXPANSIVE GROUTS: CHLORIDE PENETRATION RESISTANCE <i>Pedrosa, Filipe; García Calvo, José Luis; Carballosa, Pedro; Revuelta, David</i>	249
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>	250
189	DIAGONAL COMPRESSION TESTING OF TUFF MASONRY PANELS STRENGTHENED WITH INORGANIC-BASED SYSTEM: AN EXPERIMENTAL INVESTIGATION <i>Verre, Salvatore; Cascardi, Alessio; Gallo, Fiorella</i>	251
206	NEW GENERATION ETICS COATINGS: AN INNOVATIVE AND HIGH-PERFORMANCE CASE STUDY <i>Curado, António; Figueiras, Ricardo; Gonçalves, Hélder; Sambento, Filipe</i>	252
232	REINFORCEMENT TECHNIQUES FOR REINFORCED CONCRETE STRUCTURES <i>Guimarães, Marcos B.; Prola, Luis C.; Rodrigues, Paulo C.</i>	253
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>	254
301	EXPERIMENTAL STUDY ON BOND BETWEEN BASALT FRCM REINFORCEMENT AND CALCAREOUS STONE <i>Bramato, Giuseppe; Leone, Marianovella; Perrone, Daniele; Aiello, Maria Antonietta</i>	255
354	THE IMPORTANCE OF THE "IN SITU" BEHAVIOR OF MORTARS IN THE REHABILITATION OF BUILDINGS <i>Torres, Isabel; Flores-Colen, Inês</i>	256
361	CHALLENGES IN SAFEGUARDING AND REHABILITATION OF VILA VIÇOSA'S RELIGIOUS HERITAGE <i>Silva, J. Mendes; Ganito, Jorge</i>	257
389	BEHAVIOR OF SUPPLEMENTARY CEMENTITIOUS MATERIALS IN ELECTRO REMEDIATION PROCESSES APPLIED TO CONCRETE STRUCTURES <i>Martinez, Isabel; Castellote, Marta</i>	258
403	DIFFICULTIES IN INTERVENING ON PROTECTED HERITAGE ACCORDING TO PREFERRED STANDARDS OF REFURBISHMENT <i>Calderon Bello, Enrique</i>	259

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>	260
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>	261
100	MECHANICAL CHARACTERISATION OF VEGETAL FRCM COMPOSITES: EXPERIMENTAL AND ANALYTICAL APPROACH <i>Mendizabal, Virginia; Bernat-Maso, Ernest; Mercedes, Luís; Gil, Lluís</i>	262

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>	263
160	DESIGN AND DETAILING OF ANCHORS FOR SEISMIC ACTIONS <i>Gramaxo, Jorge; Cardo Fernández, Antonio</i>	264
164	STEEL MESH REINFORCED COATING CHARACTERIZATION FOR MASONRY UPGRADING <i>Crespi, Pietro; Cattaneo, Sara; Scamardo, Manuela; Vafa, Navid</i>	265
172	POST-INSTALLED PUNCHING REINFORCEMENT DESIGNED BY FIB MODEL CODE 2010 <i>Kunz, Jakob; Cardo Fernández, Antonio</i>	266
192	BILINEAR EXPERIMENTAL CURVE OF MASONRY WALLS MADE WITH HORIZONTAL HOLLOW BRICK UNITS <i>Díaz, Christian; Tarque, Nicola</i>	267
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>	268
350	ON-SITE REHABILITATION OF DECAYED TIMBER FLOORS WITH EPOXY-RESIN COMPOSITES <i>Bender, Tom; Schober, Kay-Uwe; Ihle, Robin</i>	269

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>	270
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>	271

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>	272
267	EXAMINING THE DEFECTS AND INTERVENTIONS IN THE COMPONENTS OF REUSED INDUSTRIAL BUILDINGS-CASE OF TURKEY <i>Çakır, H. Yasemin; Edis, Ecem</i>	273
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>	274

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>	275
24	INTEGRAL RECOVERY OF THE HERMITAGE OF SAN BLAS IN BROTO-HUESCA <i>Febas Borra, José Luís; Díez Hernández, Jesús; Rojí, Eduardo</i>	276
80	MODEST HERITAGE PRESERVATION IN SAN SALVADOR HISTORIC CENTER. THE GREEN HOUSE REHABILITATION CASE <i>Avendaño, Ayansi</i>	277
83	LIGHT AND SPACE - TRANSFORMING A VILLA INTO THE CHRISTIAN YOUTH CENTRE TIMISOARA <i>Andreescu, Ioan; Dinu, Dan – Răzvan</i>	278
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>	279
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>	280

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>	281
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>	282
178	THE RESTORATION OF SANTA CRUZ CHURCH IN ECIA (SEVILLE): THE BUILDING AS PLOT <i>Rincón-Calderón, José María; de Sola-Caraballo, Javier; Galán-Marín, Carmen; Rivera-Gómez, Carlos</i>	283
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>	284
225	PLANNING AND MANAGEMENT OF AGRICULTURE WAREHOUSE CONVERSION PROJECT: A CASE STUDY <i>Oliveira, Rui A. F.; Abreu, Maria Isabel; Lopes, Jorge</i>	285
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>	286
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>	287
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>	288

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>	291
32	INFLUENCE OF THE USERS' PERFORMANCE CRITERIA ON THE IMPACT OF MAINTENANCE OF CERAMIC CLADDINGS <i>Cláudia Ferreira; Ana Silva; Jorge de Brito</i>	292
51	METHODOLOGY FOR IMPROVING THE EFFICIENCY OF INVESTMENTS IN THE VARIOUS INDUSTRIAL INFRASTRUCTURES OF THE FORMER PORT AREA OF THE BAY OF HAVANA <i>Piñero, Ignacio; de la Cruz, Raimundo; Bresó, Juan Carlos, Cuadrado, Jesús; Ezquerro, Mikel</i>	293
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>	294
85	FEASIBILITY ASSESSMENT OF WORKING AT HEIGHT EQUIPMENT, IN RESIDENTIAL BUILDINGS MAINTENANCE <i>Di Ruocco, Giacomo; Melella, Roberta</i>	295
176	PUBLIC BUILDINGS MAINTENANCE MANAGEMENT <i>Ferreira, Léila; Paiva, Anabela; Silva, J. Mendes</i>	296
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>	297
378	DIAGNOSIS OF A MODERNIST WORK: THE "PARADOR ARISTON" <i>Valcarce, María Beatriz; Vázquez, Marcela</i>	298
388	REMOTE INSPECTION OF THE INTERIOR OF CHANNELS AND STORAGE TANKS OF THE WATER SUPPLY AND SANITATION NETWORK <i>Tárrago Garay, Nerea; Barroso Prados, Francisco Javier; Espada, Fran; Borrás Morrison, Mikel</i>	299

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>	300
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>	301
50	PRESERVING THE 20TH CENTURY INDUSTRIALIZED BUILDING HERITAGE IN ITALY: COMBINING HISTORICAL SURVEYS AND PHILOLOGICAL BIM <i>Mornati, Stefania; Giannetti, Ilaria</i>	302
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>	303
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>	304
136	ANALYSIS OF ANTHROPIC AND SOCIAL THREATS OF THE ARAB WALL OF ALZIRA <i>Guardiola-Víllora, Arianna; Basset-Salom, Luisa</i>	305
138	SLOPE STABILIZATION BY ROAD ROTATIONAL SLIDE IN THE JUNGLE OF PERU <i>Soplopucó Quiroga, Serbando; Soplopucó Torres, Rubén Ronald; Martínez Quiroz, Enrique Napoleón; Alarcón Zamora, José Evergisto</i>	306
151	CHARACTERISTICS OF THE CULTURAL HERITAGE PREVENTIVE CONSERVATION SYSTEM OF SOUTH KOREA <i>Hwang, Minhye</i>	307
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>	308
357	THE CONTRIBUTION OF DESCONSTRUCTION TO THE PRESERVATION OF PORTUGUESE OLD BUILDINGS <i>Ranna, Gabriela; Torres, Isabel; Silva, José</i>	309

5.- DIFFUSION AND PROMOTION

5.1.- Heritage and cultural tourism.

- 35 DISUSED RAILWAY STATIONS AND BUILDING AND ENVIRONMENTAL RECOVERY STRATEGIES
Radogna, Donatella 313
- 47 INDUSTRIAL HERITAGE IN THE PROVINCE OF ALMERÍA. ANALYSIS AND REUSE FOR A SUSTAINABLE TOURISM
García-Ruiz, Almudena; García-Ruiz, Luisa-María; Sáez-Pérez, María-Paz 314
- 49 EVOLUTIONARY, MORPHOLOGICAL AND ACOUSTIC ANALYSIS OF CLASSICAL GREEK THEATRES. PARAMETERS FOR PRE-DIMENSIONING AND REHABILITATION
Mesto, Suleiman; Rubio, María Jesús 315
- 87 AN EXAMPLE OF THE ANALYSIS OF RURAL SETTLEMENTS: ASAGI BELEMEDIK VILLAGE
Ortakaya, Esra Nur; Umar, Nur 316
- 109 PROPOSAL FOR INTERVENTION IN ABANDONED ARCHITECTURE: THE ROMAN TEMPLE OF VIÑEROS IN THE CITY OF MÉRIDA
Agudo Martínez, Andrés; Fernández Castelló, Francisco; Vázquez Sánchez, Gloria 317

5.2.- Teaching and training.

- 188 ADVANTAGES OF FLIP TEACHING ACTIVE METHODOLOGY DURING THE COVID-19 PANDEMIC
Tuesta Durango, Nelson; Villanueva Valentín-Gamazo, David; Mansilla Blanco, M^a Isabel; Rey de las Moras, M^a Cruz; Cantalapiedra Cantalapiedra, Ángel; Martínez Iranzo, Fco. Javier 318

5.3.- New technologies applied to the heritage diffusion.

- 12 INVENTORIES FOR THE PRESERVATION AND DISSEMINATION OF THE ARCHITECTURAL HERITAGE
Quintilla, Marta; Agustín, Luis 319
- 27 THE GEOMETRIC APPEARANCE OF COLUMNS AND FRAMES IN THE PALATIAL OTTOMAN ARCHITECTURE OF THE ALGIERS CASBAH: WHAT PROCESS TO CREATE?
Aïcha, Bibimoune; Samia, Chergui 320
- 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)
Collado-Espejo, Pedro-Enrique; García-León, Josefina; González-García, Jesús Ángel 321
- 113 3D MODELING AS A VALIDATION SYSTEM FOR THE RECONSTRUCTION OF THE DISAPPEARED HISTORICAL ARCHITECTURAL HERITAGE: THE OCTOGON OF VALLADOLID
Villanueva-Valentín-Gamazo, David; Arcones-Pascual, Gustavo; Bellido-Blanco, Santiago 322
- 286 MIXED VIRTUAL TOUR FOR THE DISSEMINATION OF THE DECONTEXTUALIZED HERITAGE. THE OVIEDO CATHEDRAL CHOIR STALLS
Sánchez Riera, Alberto; Pàmies, Carles; Navarro, Isidro 323
- 291 DEFENSIVE ARCHITECTURE, DIFFUSION AND NEW TECHNOLOGIES. ANALYSIS OF THE NATIONAL PARK SERVICE AND PARKS CANADA STRATEGIES
Mira Rico, Juan A. 324
- 304 MALAKA.NET AS A COMPREHENSIVE WEBGIS PLATFORM TO MANAGE CULTURAL HERITAGE. A COMPARATIVE CASE STUDIES
Conejo-Arrabal, Francisco; Chamizo-Nieto, Francisco José; Rosa-Jiménez, Carlos; Nebot-Gómez de Salazar, Nuria 325
- 312 A COMPARATIVE STUDY BETWEEN A STATIC AND A MOBILE LASER SCANNER FOR THE DIGITALIZATION OF INNER SPACES IN HISTORICAL CONSTRUCTIONS
Villanueva Llauredó, Paula; Maté González, Miguel Ángel; Sánchez Aparicio, Luis Javier; Benito Pradillo, María Ángeles; González Aguilera, Diego; García Palomo, Luis Carlos 326
- 317 THE INTANGIBLE CULTURAL HERITAGE THROUGH DIGITAL INVENTORIES. CASE STUDY IN MÁLAGA, SPAIN
Nebot-Gómez de Salazar, Nuria; Chamizo-Nieto, Francisco José; Conejo-Arrabal, Francisco; Rosa-Jiménez, Carlos 327

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
Máximo, Marco Aurélio da Silva; Ferreira, Oscar Luís 328

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>	329
209	THE RESILIENT CONSTRUCTION SITE OF THE HISTORICAL CENTERS. A CASE STUDY <i>Rotilio, Marianna; Laurini, Eleonora; De Berardinis, Pierluigi</i>	330
210	GUNPOWDER HOUSE - VALPARAÍSO AN URBAN ARCHAEOLOGICAL SITE AND ITS HERITAGE RECOVERY <i>Kaplan, Paulina</i>	331
215	REVIEW OF THE MANAGEMENT OBJECTIVES OF THE WORLD HERITAGE DECLARATION OF ÚBEDA AND BAEZA <i>Hervás-Molina, María; Loren-Méndez, Mar</i>	332

KEYNOTE LECTURES

KEYNOTE LECTURE 1

THE USE OF TITANIUM IN CONSERVATION AND SEISMIC REINFORCEMENT OF MASONRY STRUCTURES

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KEYWORDS: Historic masonry structures; Earthquake engineering; Titanium alloys; Retrofit.

ABSTRACT

Reinforcement of masonry buildings and infrastructures to meet structural safety requirements and new building codes has become a priority in the field of structural and earthquake engineering. A number of applications of titanium retrofits for use in civil engineering structural systems is described in this article. New advanced materials (composite materials, stainless steel, natural fibres) are being widely researched for repair and rehabilitation in civil engineering structures, but little research has been conducted regarding titanium alloys. The potential benefits, liabilities, and architectural considerations regarding the use of titanium alloys for reinforcing masonry structures are discussed with an emphasis on in-plane shear loading and out-of-plane bending. This paper therefore presents the state of the art in the use of titanium profiles in retrofitting masonry structural elements within historic structures. It includes a review of the development of the retrofitting methods and existing experimental studies on the mechanical behavior of masonry structures reinforced with titanium. Finally, it presents a number of case-studies and draws conclusions on current trends and practices based on reported studies.

KEYNOTE LECTURE 2**STRENGTHENING OF MASONRY STRUCTURES WITH INORGANIC MATRIX COMPOSITES (IMCs)****Aiello, Maria Antonietta**

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e-mail: antonietta.aiello@unisalento.it**KEYWORDS:** Inorganic Matrix Composites; Masonry; Durability; Retrofitting; Structure.**ABSTRACT**

Nowadays rehabilitation of existing masonry buildings has a key-role in the field of civil constructions, as a large part of them is dated back over centuries and in many cases protected by heritage institutes. On the other hand, Rehabilitation and Sustainability complement each other since reuse of old buildings avoids the disposal and its consequent environmental impact and prevent the expansion of built environment, furthermore conservation is becoming a priority to deliver the built cultural heritage in good shape for the future generations. In this context, the interest in adequate materials and techniques for structural rehabilitation has steadily grown in recent years, aiming to guarantee safety requirements, extending the building service life, limiting the environmental impact. The use of Steel Reinforced Mortar (SRM) and Fiber Reinforced Polymer (FRP) have been experienced as strengthening techniques for masonry structures in the past. SRM has widely evidenced its vulnerability to electrochemical corrosion while FRPs have been proved to be hardly compatible with historical masonry not only from a mechanical point of view but also because of the application of that material often does not accomplish the stringent rules of conservation and limits the breathability of the existing masonry. A new generation of systems and materials, namely Inorganic Matrix Composites (IMC), consisting in a fiber mesh or FRP grid, combined with mortar, seems able to overcome the mentioned drawbacks. The main features of these emerging materials and systems will be presented. In particular, the main focus will be done on the confinement of masonry columns and shear strengthening of masonry walls, introducing also the potential use of new green mortar able to make the strengthening systems effective in contributing to energy retrofitting. In addition, durability issues will be discussed, being at the moment the major gap within the scientific knowledge.

KEYNOTE LECTURE 3

PROGRESSIVE COLLAPSE AND ROBUSTNESS OF BUILDINGS AND BRIDGES

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KEYWORDS: Progressive collapse; Robustness; Buildings; Bridges.

ABSTRACT

As a result of the persistent occurrence and apparently increasing frequency of catastrophic structural failures, recent years have been marked by a growing body of literature on progressive collapse and structural robustness. At present, the vast majority of these studies focus on computational simulations and laboratory testing of reduced-scale sub-assemblages. Although many vital aspects of structural behaviour under extreme conditions have been uncovered through such research, these strategies are characterised by significant limitations which can only be overcome through full-scale testing of real structures. This article presents some of the major research works performed in this regard by the *Building Resilient* research group from the *ICITECH* institute of the *Universitat Politècnica de València*. The most important works related to temporary shoring of buildings, cast-in-place and precast reinforced concrete building structures, steel truss bridges, and fuse-segmented buildings are presented together with the most significant results achieved so far.

KEYNOTE LECTURE 5**ARCHITECTURE OF MANY EPOCHS:
THE SACROMONTE ABBEY IN GRANADA****Martín Muñoz, Antonio**

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KEYWORDS: Heritage; Rehabilitation; Abbey; Granada; Sacromonte.

ABSTRACT

Much has been written about the surprising discoveries that motivated the foundation and development of the Sacromonte Abbey. While not being part of the public domain, one can verify how important authors such as Cervantes, in Don Quixote, or Luis de Góngora, with his sonnet to the Holy Mountain of Granada, were already addressing this topic at the time. To name all the other existing publications on this subject to date, we would need several pages. The four centuries of the Sacromonte Abbey's history include, like in all institutions, periods of thrive along with others of decline or stagnation: lights and shadows.

Nevertheless, there is not much documentation regarding the construction process of the Abbey, the development of the different buildings, and the countless alterations that are evident in the current structure.

This article reviews the events that impacted the Sacromonte Abbey at the end of the 16th century and its initial consequences, reviews the construction that followed, and provides a specific overview of the most recent significant intervention carried out in this monumental building complex. The rehabilitation and adaptation of the Reception Building recently completed, created a central and nucleus space and addressed key structural, material and even aesthetic deficits. In addition, the rehabilitation implemented accessibility and building connectivity improvements along with facilities, utilities and other upgrades that resolve many of the endemic deficiencies of the Abbey.

KEYNOTE LECTURE 6**CONSERVATION AND MANAGEMENT OF THE BUILT HERITAGE: RECENT WORKS ON MODERN HERITAGE BUILDINGS OF PORTUGUESE ORIGIN****Lourenço, Paulo B.¹; Mendes, Nuno¹; Ortega, Javier¹**

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KEYWORDS: 20th-century built heritage; Conservation management plan; Concrete; Inspection and diagnosis; Non-destructive evaluation.

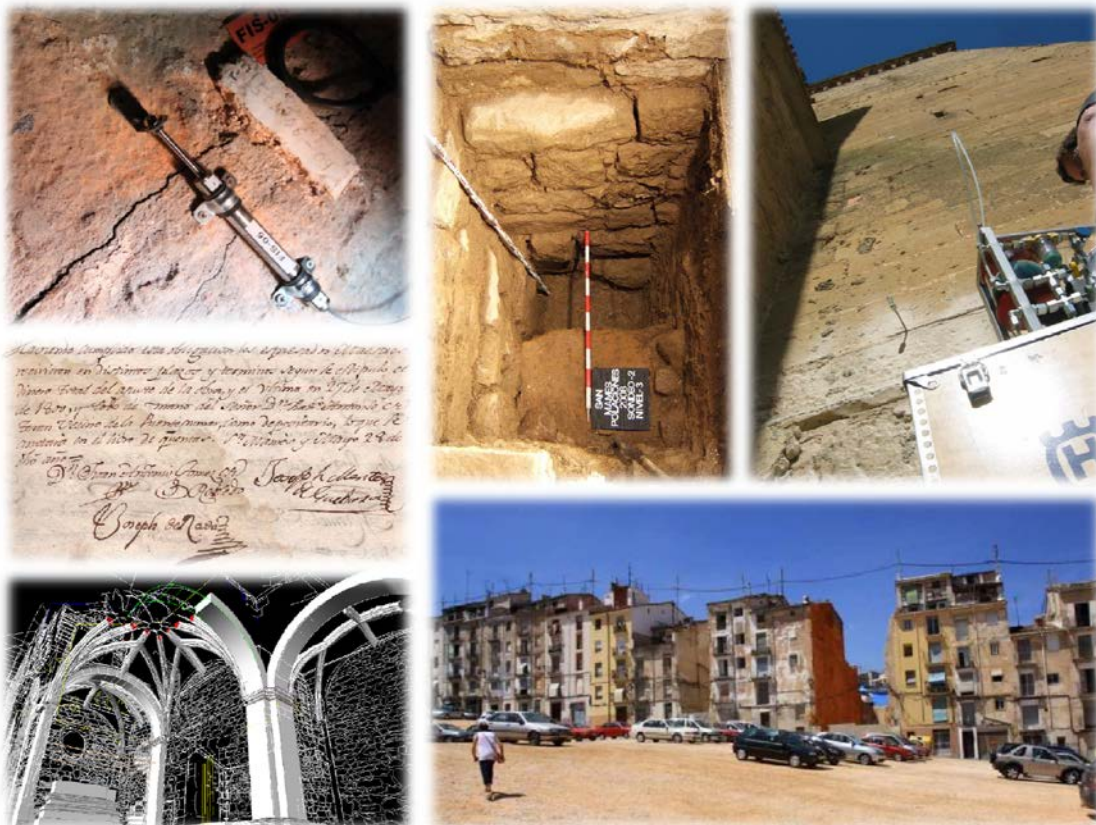
ABSTRACT

Our built heritage is at risk, and this crisis requires professionals who have the ability to protect our shared heritage from various threats, including natural decay, human interventions, climatic changes, and natural hazards. Specialized expertise is necessary to advance protection of built cultural heritage - formerly a niche area, now increasing in importance. We need professionals able to understand structural systems in different cultural contexts, and we must encourage them to develop their expertise with a valuable international perspective. These trained professionals have their own intrinsic market value, with knowledge often not possessed by regularly trained engineers and architects. This knowledge includes techniques of seismic retrofitting that can be extended into any existing building, not just historic fabric; forensic engineering skills such as inspection, diagnosis, and arrest of deterioration and damage in various forms of historic construction; in-depth knowledge of survey techniques; and good writing and communication skills.

This paper addresses the definition of an integrated methodology for preventive conservation of historic buildings, the leverage of advanced technologies for the implementation of the methodology and standardization of methods and tools through the development of rules of “good practice”. This is a must to raise public awareness about the societal and economic benefits associated with the adoption of regular preventive conservation actions. For this purpose, two recent works in modern heritage buildings and their conservation management plans will be addressed. The first one is in Beira, Mozambique, which witnessed some of the most important projects of the Modern Movement in the Colonial Portuguese Africa, namely its train station. The building was considered among the one hundred more important 20th century Portuguese engineering buildings. The most striking sector of the complex is the atrium of the train station, with a large vault, asymmetrically juxtaposed to the office building and creating a large volume. The second one needs no further details, as one of the earliest works of the renowned Portuguese architect Álvaro Siza, the Swimming Pool in Leça.

1.- PREVIOUS STUDIES

- 1.1.- MULTIDISCIPLINARY STUDIES (HISTORICAL, ARCHAEOLOGICAL, ETC.).
- 1.2.- HERITAGE AND TERRITORY.
- 1.3.- URBAN REGENERATION.
- 1.5.- SOCIAL PARTICIPATION PROCESSES AND SOCIO-CULTURAL ASPECTS IN REHABILITATION PROJECTS.
- 1.6.- CONSTRUCTION PATHOLOGY.
- 1.7.- DIAGNOSTIC TECHNIQUES AND STRUCTURAL ASSESSMENT (NO DESTRUCTIVE TESTING, MONITORING AND NUMERICAL MODELING).
- 1.8.- VULNERABILITY STUDIES AND RISK MANAGEMENT.
- 1.9.- GUIDES AND REGULATIONS.



CODE 3**CHROMATIC ANALYSIS OF THE FINISH OF THE 17TH CENTURY WALL OF THE SANTO DOMINGO FORTRESS IN DOMINICAN REPUBLIC**

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KEYWORDS: Colour; City wall; Fortress of Santo Domingo; Non-Destructive Techniques; Dominican Republic.

ABSTRACT

The defense system of the city of Santo Domingo, Dominican Republic, began in 1503 with the construction of the fortress and Tower of Homage. In 1567 the wall that encloses the fortress was completed, and around 1653 the platform or shooting battery was built at the bottom of the fortress. The rest of the walled system of the city of Santo Domingo was begun in 1543 and took about 200 years to complete, after several interruptions. This military architecture has been little studied, including its chromatic finishes that had an impact on the general perception of the urban landscape. In this article, a chromatic analysis of part of the finish of the 17th century wall of the fortress of Santo Domingo is carried out by performing nondestructive tests on six stratigraphic coves. Additionally, optical, chemical, mineralogical and microstructural analysis was carried out, using UV-VIS-NIR Spectrophotometry, Raman Spectroscopy, X-Ray Diffraction (XRD), Scanning Electron Microscopy with energy dispersive X-ray microanalysis (SEM/EDX), Munsell Color System and Digital Colorimeter. The results obtained have allowed to obtain the quantitative characterization of the color of each paint layer and the chemical composition of the pigment used in each case. By relating the data with its historical evolution, they help to better understand the military complex and provide essential information to address the restoration tasks.

CODE 16**DEVELOPMENT OF THE CONSTRUCTION SYSTEM OF THE SOUTHERN
GOTHIC CATHEDRAL PROFILE****Lluís-Teruel, Cinta¹; Lluís i Ginovart, Josep²**

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e-mail: jluis@uic.es, web: <http://www.catedrajlg.com>**KEYWORDS:** Gothic; Cover; Cathedral; Council of Trent; Opus Ceamenticium.**ABSTRACT**

The paper discusses the structural evolution of Gothic roofing. The image of the medieval cathedral had preserved the sloping roof profile of the Constantine basilica, this aesthetic contrasted with the flat-profile roofs of the cathedrals of Southern France alluded to by Viollet-le-Duc and Robert de Lasteyrie, and those of the Spanish Levant referred to by George Edmund Street. The roof of these buildings has been evolving since the 13th century for technical and liturgical reasons until the end of the 20th century, the firstborn state, influenced by the Nara Document in Authenticity (1994).

The analytical method determines the evolution of these roofs, initially were built on a base of opus ceamenticium to which Alberti refers, evolved towards ventilated roofs with a ceramic finish. With the Counter-Reformation, they were transformed into sloping roofs with a tile finish, in an attempt to reproduce the image of Constantine's basilica. This profile and roof were again transformed at the end of the 20th century, recovering the original flat geometry.

As results it is concluded that with the passage of time these silenced and overlapping authorships, have responded to the criteria of the representativeness of the Church in the city and liturgical aspects, but also to new technical solutions and sustainable adaptation, until introducing the heritage values of the Nara Document in Authenticity (1994), recovering the original profile in some cathedrals such as Tortosa (1998), Girona (2000) and Valencia (2005). The constructive evolution of these processes is thus addressed, with special emphasis on the evolution of the Gothic roofs of the cathedral of Tortosa (1383-1998), where this process of building, deconstructing and rebuilding the image of the flat profile is evident, also recovering the values of the sustainable criteria of insulation, lighting and especially ventilation.

CODE 20**THE HOROLOGION OF ANDRONIKOS OF KYRROS IN ATHENS, GREECE:
CULTURAL HERITAGE ISSUES AND HISTORICAL EVIDENCE****Panou, Evangelia¹; Alexopoulou, Athina Georgia²**

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KEYWORDS: Horologion of Andronikos; Tower of the Winds; Ancient Greek science and cultural knowledge; Cultural heritage issues and conservation; Graffiti on stones.

ABSTRACT

The purpose of the present work is to reveal the connections arising from understanding cultural heritage issues and draw conclusions concerning the historical use of the Horologion of Andronikos of Kyrros throughout centuries. The Horologion of Andronikos, also known as the Tower of the Winds, is an important well-preserved monument of the early 1st century B.C. which dominates in the historical centre of Athens, Greece, under the north slope of the Acropolis of Athens. The stone surfaces of the monument have been systematically and thoroughly recorded using modern imaging techniques and new evidence on the stone surfaces such as drawings, engravings, ship graffiti, decoration details detected. Moreover, micro-samples were taken from the internal stone surfaces of north and southeast-facing walls using scanning electron microanalysis and new evidence concerning the colors and the pigments on stones surfaces revealed. The obtained results are presented and discussed in the present work and the documentation of the uses of the monument follows.

CODE 33**RESTORATION AND ACCESS TO THE INCA CEREMONIAL SANCTUARY OF MAUCALLACTA AND ITS INSERTION IN THE TOURIST CIRCUIT OF SOUTHERN PERU****Cusihuamán Sisa, Gregorio Nicolás¹; Alarcón Condori, Javier Guido²**

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Email: jalarconc@unsa.edu.pe**KEYWORDS:** Restoration; Inca ceremonial sanctuary; Intangible heritage; Tourist circuit; Maucallacta.**ABSTRACT**

The research analyzes strategies that make visible the need to restore the ceremonial sanctuary of Maucallacta, at 3,700 meters above sea level. With an area of 2.5 hectares, it consists of 250 stone constructions, among which are the ceremonial center, Ushnu, Kallanca, Mausoleum, Colcas and pyramids, built in the early stage of the Inca empire, whose characteristics maintain traits of a millennial culture of the Hike from Arequipa to the south of Peru, in front of the ceremonial center is the natural attraction Nevado Coropuna at 6,425 meters above sea level with perpetual snow, considered one of the sacred mountains of Peru. The study proposes strategies that make visible the historical attractions and road accesses of the Inca Trail, committing to the southern tourist circuit; In turn, it highlights the intangible heritage recognized in the rural district of Pampacolca, at 2,916 meters above sea level, which is 252 kilometers from the city of Arequipa. The methodology developed is a documentary research contrasted with the empirical evidence of the Maucallacta sanctuary, which to date shows the abandonment of its facilities and the difficult access. The archaeological analysis of the University of Warsaw shows that the construction dates from the fifteenth century, however the road connection that articulates the southern tourist circuit is still pending, the research shows the economic advantages of including the geopark of the Andagua volcanoes considered as heritage natural with 400 million years of formation, the Colca canyon, the petroglyphs of Toro Muerto, the dinosaur footprints and the ceremonial sanctuary of Maucallacta articulating the tourist development of the south, with the sanctuary of Machupichu and Lake Titicaca; This could strengthen the economy of the rural sectors, improve the quality of life of the committed populations of the surrounding regions and promote historical ecotourism in southern Peru, as well as the promotion and consumption of native organic agricultural products.

CODE 34**THE CITY OF SUCEAVA - ASPECTS OF URBAN DEVELOPMENT****Cioban, Andreea G.¹; Agachi, Mihaela I. M.²**

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e-mail: mihaela.ioana.agachi@arch.utcluj.ro**KEYWORDS:** Urbanism; Territory; City; Heritage.**ABSTRACT**

The paper aims the development of the city of Suceava, located in northern Romania, in the historical region of Bukovina. This city has been documented since 1388. The current territory of Suceava and its surroundings have been inhabited since the Paleolithic, and in the second and third centuries here there was a settlement of the free Dacians, strongly influenced by Roman neighborhoods. The geographical context explains the existence of this settlement, important market place of exchange, and then capital of Moldova, at the end of the 14th century. Suceava became a main administrative center, crafts, as well as an important Orthodox religious center. The existing oldest churches and monasteries in the city, now classified as historical monuments, were erected at that time. The city has developed since the medieval period (14th century), around these churches and monasteries. Because of the favorable location from a strategic point of view, there was erected an important fortress here, in defense against the frequent Tatar, Polish and Ottoman incursions. Historical vicissitudes have caused periods of eclipse. Thus, between the 16th and 17th centuries, the city lost its status as the capital of Moldova. During the Habsburg occupation it became an important and modern city within the Duchy of Bukovina. (the 18th century). We present some fluctuations of the urban structure of the city related to the surrounding area of a monastery, a specific and not isolated case, in order to follow the evolution of the related urban fabric. Our work is part of a broader research, which aims at the historical-urban development of Suceava, especially from the Middle Age to nowadays, a period in which historical data and topographic representations allow a complex knowledge of urban development.

CODE 65**THE HISTORIC ARCHITECTURAL COMPLEX OF MANGUINHOS,
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KEYWORDS: Conservation; Urban; Cultural; Scientific; Heritage.**ABSTRACT**

The historic architectural complex of Manguinhos is an important symbolic architectural complex in Brazil. It is the headquarters of the Oswaldo Cruz Foundation - Fiocruz, and it was protected by the National Historic and Artistic Heritage Institute (IPHAN) in 1980.

The construction of the complex started in 1904 on the initiative of the famous Brazilian physician, sanitarian and scientist Oswaldo Cruz, who was an intern during three years, starting in 1886, at the Pasteur Institute in Paris.

Designed by the Portuguese architect Luiz Moraes Júnior, it was originally composed of the Moorish Pavilion, Stable, Plague Pavilion, Quinine, Aquarius, Vivarium for small animals and Evandro Chagas Hospital.

The architectural ensemble adopted the eclectic language and received the most varied influences of monuments, styles and decor: Alhambra (Granada, Spain), Montsouris Observatory (Paris, France), English railway stations, Moorish architecture (Iberian peninsula, 11th - 15th centuries), Elizabethan architecture (England, second half of the 16th century), the Tudor style (England and Wales, 1485 - 1603), and art nouveau (1890 - 1910).

This article aims to analyze the architectural language adopted; the materials and building systems used; its meaning for the city; the surrounding environment at various periods; and the physical, functional and visual relationship with the city.

The article also aims to analyze the following issues:

- Considering the vision of Brazilian modernists who, in search of an identity for Brazil, recognized the work of Aleijadinho (*) as an expression of genuine Brazilian art, to what extent did the European eclecticism influence a retrocession in that process of construction of a national identity?
- What was the role of the European eclecticism in sense continuity of a cultural colonization process in the world and particularly in Brazil ?

In the conclusion, this article aims to analyze the architectural language adopted in Alhambra, Spain and in the Moorish Pavilion, Brazil.

(*) Antonio Francisco Lisboa, known as Aleijadinho, was defined by the French art historian Germain Bazin as the "Michelangelo of the Tropics".

CODE 95**HISTORICAL ARCHIVE OF THE CITY OF LOJA, ECUADOR****Delgado Cruz, María José ¹; Sanz González, Sofia²**

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e-mail: ssanz@utpl.edu.ec, web: <https://investigacion.utpl.edu.ec/ssanz>**KEYWORDS:** Loja; Study; Ecuador; Historical archive.**ABSTRACT**

The focus of this article is to understand and disseminate the importance of historical archives, especially in reference to that of the city of Loja, a city located in southern Ecuador. This institution helps researchers and society in a concrete and real way, to determine what were the facts that marked its history. In Ecuador there is a significant delay in relation to the management of historical archives, compared to those existing in other countries, because the information has a rudimentary treatment, the archive must be attended and have direct access to the fund, which may compromise its conservation status, which hinders its accessibility and prompt reading, delaying the knowledge and research in the country. This information generates possibilities to realize the objectives proposed in a doctoral study, about how the city and the architecture of Loja was during the early nineteenth century, especially when it is a time when important events occurred such as; the independence deeds, Loja becomes a landmark for the country when the Federal Government of Loja becomes. Finally, in the Historical Archive of Loja primary information was found unpublished documents, which come from different governmental institutions, and which are already organized, classified and cataloged, to begin with its analysis.

CODE 148**MEXICAN TEMPLES OF MENDICANT CONVENTS: STRUCTURAL CONFIGURATION AND DAMAGES DUE TO EARTHQUAKES****García Gómez, Natalia^{1*}; Peña Mondragón, Fernando²; Chávez Cano, Marcos M.²**

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e-mail: fpem@pumas.iingen.mx, mchvezc@pumas.iingen.mx, web: <http://www.iingen.unam.mx>**KEYWORDS:** Architectural heritage; Masonry ancient structures; Masonry vaults; Spanish Colonial architecture; Mexican churches.**ABSTRACT**

This article studies the structural configuration of conventual temples built in the state of Morelos during the 16th century by the Franciscan, Dominican and Augustinian mendicant orders. For which, the materials, types and arrangement of its structural elements are considered, as well as some of its most relevant transformations. The main objective is to identify its relationship with the damage caused by recent earthquakes, particularly the one that occurred on September 19, 2017. A preliminary relationship, at a qualitative level, is made between the observed damage and the original structural characteristics of the buildings, as well as some relevant changes that could influence the effects due to seismic movements. For this study, the temples were classified according to the type of roof of the nave and, as support to explore the possible original conception of the structure, old rules were revised to determine the dimensions of structural elements of masonry.

CODE 150**BLURRED FAÇADE AS THRESHOLD ARCHITECTURE****Yapicioglu, Balkiz¹; Cazacova, Liudmila^{2*}**

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KEYWORDS: Architecture threshold; Blurred façade; Culture and traditions; Privacy; Burqa.

ABSTRACT

At architecture thresholds, stimuli from internal spaces can spill over to the external ones and vice versa, where sense of invitation and understanding of the interior from the exterior is intended. However, there are some incidences where the thresholds might not be so obvious. This study originates from the tradition and history of Omani burqa and explains how contemporary residential housing façade in Dhofar Region in Oman resembles the tension between the traditional and contemporary veil, and aims to show that architecture façade design studied in this research manifests itself as a blurred threshold, between the past and the present, rather than a transition between the interior and the exterior. This research, initially, reviewed exhibitionism and veiling contradiction in Arab Culture (mostly in the Gulf region) with references to the emergence of modern style trends in burqa/veil design in Oman to make the connection in how tension between modernization and tradition has created blurred thresholds in contemporary façade architecture design. This research uses an anthropological approach, a qualitative approach, and by applying the parameters of threshold and visual analysis of house façades and evaluation of traditional and contemporary façade elements in Salalah Oman, the study attempts to show that, the façade of residential housing in Oman is a blurred threshold and is designed to accentuate visibility, hindering what is behind, and not to serve as stimuli of invitation.

CODE 194**OPTICAL AND COLOR ANALYSIS OF ROMAN WALL PAINTINGS FROM THE
FORUM DISTRICT OF CARTHAGO NOVA**

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KEYWORDS: Chromatic measurement; Optical microscopy; In-situ analyses; Stucco; Pigments.

ABSTRACT

Wall painting is a decorative technique used by most ancient cultures. Nowadays, valuable pictorial remains are preserved in public and private buildings in the ancient Roman colonies. Unfortunately, most of these wall paintings have been discovered in fragments and only a few are still intact in panel form. In recent decades, studies have been carried out on Roman wall paintings mainly from Western Roman Empire. Studies of the Roman wall paintings from the main colonies of Hispania, as for instance Cartago Nova, have been reported in the literature. However, analytical results about the characterization of their pictorial surface are scarce. This communication is a preliminary study of wall paintings from the archaeological site of the Forum District (1st century A.C.) in the Roman Colony of Carthago Nova. It comprises several buildings, including the Atrium which probably corresponds to a corporate headquarters –schola– or meeting and organizational place for a religious association. This paper aims to provide useful information about the texture and color of the wall paintings based on a multi-analytical approach about the pictorial surfaces by imaging techniques, such as Optical Microscopy (OM) and Colorimetry (CIE-Lab). The used panel of colors is examined and a comparative study of each color is carried out within several rooms of the monument. The results may shed light on the nature, quality and state of conservation of the remains of mural paintings preserved in the archaeological site.

CODE 283**DOCUMENTARY RESEARCH AND CONSTRUCTIVE UNDESTANDING OF THE
PICASSO AND NESJAR MURALS IN THE BUILDING OF THE ARCHITECTS'
ASSOCIATION OF CATALONIA IN BARCELONA, SPAIN**

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KEYWORDS: Primary sources; Concrete; Sgraffito; Documentary research.

ABSTRACT

In 1958 the architect Xavier Busquets won the competition to build the new headquarters of the College of Architects of Catalonia in the heart of the city of Barcelona (Spain). The project incorporates five elements, the work of Pablo Picasso and Karl Nesjar, in white sandblasted sgraffito concrete, consisting of three friezes as a façade plinth and enclosure of the auditorium and two murals in the interior as cladding of the "foyer". Recently, the need for a diagnostic study of the state of conservation was determined as a previous step to its restoration.

In this communication we present the part of the documentary research and the search for sources that have allowed us to understand the construction process, the materials and the result of the artistic production that composes the architectural/constructive ensemble.

CODE 290**THE FIRST APPROACH TO TRENCADÍS OF GAUDÍ: METHODS OF GEOMETRIC ANALYSIS****Asadova, Zahra^{1*}; Navarro, Isidro¹; Santana, Galdric¹**

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e-mail: zahra.asadova@upc.edue-mail: isidro.navarro@upc.edue-mail: galdric.santana@upc.edu**KEYWORDS:** Photogrammetry Software; Comparison Analysis; Trencadís; Gaudí.**ABSTRACT**

The research presented in this paper consist in exploring the technological and thematic origins of constructive elements of Gaudí's buildings, which made by using trencadís mosaic technique. This article is a first approach to analysis the technique by using photogrammetry method.

As an example, was used, bench in which is located in Torre Bellesguard, which will be analysed, with photogrammetry technique. To obtain the better results had been used comparison of the main commercial software programs has been used, applying methods, comparison and phases of work organized in analytic processes.

The aim of the analysis is to find more correct and suitable to use software at the first stage of the research. Its future application will be second phase that will be directed directly to the main object of research - analysis of the Park Guell bench -one example where the use of the trencadís technique has reached its maximum splendour.

CODE 294**SANTA COLOMA D'ANDORRA
THE CONCEPTION OF A CHURCH BEFORE THE 11TH CENTURY****Pedragosa Batllori, Gemma^{1*}**

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e-mail: gemma.pedragosa@upc.edu**KEYWORDS:** Early Middle Ages; Religious Architecture; Architectural Composition; Proportion.**ABSTRACT**

The church of Santa Coloma d'Andorra belongs to one of the oldest and simplest architectural types of religious architecture: that of a single rectangular nave and square apse. However, the simplicity of this type should not necessarily be associated with lack of knowledge or building methods.

The objective of this study is to determine the degree to which the architecture of Santa Coloma responds to complex metric elaboration. It is highly probable that the complexity can be related to the cultural level in Santa Coloma, due to its proximity to two important cultural centers of the time the Diocese of Urgell & Sant Serni de Tàvernoles Monastery.

In this work, architecture was used as an archaeological material to analyse the key elements of the structure. Historiography has been handled, plans drawn up, the unit of measurement found, and its dimensions studied in relation to the knowledge of proportion of the moment and the descriptions of biblical buildings. And this resulted in the fact that to conceive, plan and build this church, it was necessary to know both the architecture represented in the Bible and the arithmetic methods compiled by Boethius and Cassiodorus in the sixth century.

We see, therefore, a building that although is rural and apparently simple, responds to layout design and proportions found in specific symbolic language. This means the buildings themselves reflect and document how knowledge was understood and are fundamental to our understanding of the time in which they are built.

CODE 297**ANALYSIS AND PROPOSAL FOR RECOVERY OF ARCHITECTURAL HERITAGE. THE CASE OF THE TEMPLAR COMMANDRY OF ABERIN IN NAVARRE****Roces Gonzalo, Clara¹; Torres Ramo, Joaquín²**1: Escuela Técnica Superior de de Arquitectura
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Universidad de Navarrae-mail: jtorram@unav.es, web: <https://www.unav.edu/web/escuela-tecnica-superior-de-arquitectura>**KEYWORDS:** Architectural heritage; Recovery; Holistic methodology; Templar commandry; Aberin.**ABSTRACT**

This paper gathers the research focused on the Templar commandry of Aberin (Navarre), monument included in the Red List of Heritage drawn up by the association Hispania Nostra, with the objective of developing a methodology oriented towards the recovery of architectural heritage at risk of disappearance.

Following the proposed methodology and with the main objective of giving a holistic view of the case, it will be analysed from three perspectives that highlights its most notorious aspects (historical, social, technical) then followed by the proposal of a methodology suitable for the case. It will be based on the integration and complementarity of the different studied fields that will be gathered in an action plan. Subsequently, solutions applicable to the main problems observed in the case study will be developed in detail: structural cracks and different types of humidity (capillarity, infiltration, runoff, hygroscopicity of the material) as well as the lack of outreach of the monument.

It will conclude with some key ideas drawn from the process that allow establishing the favourable or unfavourable viability of the proposed rehabilitation and demonstrating the translatable nature of the methodology as well as justifying the protection of the studied monument and other similar cases.

CODE 318**ARCHAEOLOGY OF ARCHITECTURE APPLIED TO CONSERVATIVE
ARCHITECTURAL RESTORATION: CASE STUDY OF STRATIGRAPHIC
ANALYSIS OF VOLUMES AND COATINGS****Cascone, Santi Maria^{1*}; Longhitano, Lucrezia²; Longhitano, Giuseppe Antonio³**

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e-mail: archgalonghitano@gmail.com**KEYWORDS:** Stratigraphy; Archeology of architecture; Restoration; Mortars; Preservation.**ABSTRACT**

The importance of multidisciplinary studies of the historical architectures functional for restoration is now well established and widespread on a theoretical level and is increasingly affirming itself also in practice. An interdisciplinary approach to historical monuments allows one to have a deep knowledge of the monument, which is recognized as necessary for the subsequent elaboration of the restoration project, to operate in compliance with the history of the building and trying to limit irreversible errors. A fundamental contribution, part of this phase of knowledge, is the contribution given by the archaeology of architecture, with the analysis of the stratification of the constructive parts and its mortars. Studying and understanding carefully the stratifications of the parts of the monument, represents a preliminary phase useful and necessary to the successive choices of restoration. Specifically, knowing the stratification of coatings, allows us to collect the historical and material data necessary for the subsequent project choices like is the formulation of mortars for restoration. Through the study of an important architecture of Catania -the eighteenth-century palace of the Biscari Princes- the aim is to address mentioned topic, showing the methodological process applied in the stratigraphic study of the walls which brought interesting information on the history of the building and useful data to know before restoring the parts.

The case study makes it possible to highlight the potential inherent in collaboration between different disciplines to know as much as possible the historical monumental heritage on which it is necessary to intervene by providing a valuable aid to the design.

CODE 330**USE VALUE VS TECHNICAL REQUIREMENTS. METHODOLOGY FOR ASSESSING POTENTIAL USES IN HERITAGE BUILDINGS. THE CASE OF LUCENA (CORDOBA)**

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KEYWORDS: Adaptive reuse; Built heritage; Functional value; Medium-sized cities; Municipal buildings.

ABSTRACT

The present study aims to propose a methodology for adaptive reuse in municipal buildings in medium-sized cities. This investigation has been developed as part of the Strategic Plan for Intervention and Reuse of the municipal buildings of Lucena (Cordoba, Spain). Moving beyond the strictly utilitarian character of the historical object defended by Riegl, the use-value of Cultural Heritage has been established as a criterion of analysis. The advantage of this method was to evaluate the potential uses not yet activated, following the theory of cultural change or adaptation.

Also, the additional conservation effort and functional value of these properties have been assessed, seeking to give continuity to the original and traditional functions of the building to reinforce its cultural significance. Therefore, the current study adopts the case study approach of the intervention plan for two municipally owned buildings in Lucena. Both are listed or proposed for their inclusion: La Tercia and the old winery Los Víbora. The research establishes a list of possible uses and the necessary interventions for rehabilitating each of these buildings, representatives of the extensive industrial legacy of the city of Lucena, based on their typological, constructive, and structural characteristics, together with their state of conservation.

Additionally, the study has relied upon participant observation to examine the degree of recognition of these edifications within the collective needs of the population of Lucena. In both cases, they have lost their original use, due to their poor conservation. In this sense, they could be considered to have lost their functional validity. However, in a broad understanding of the use-value, the work has aimed to establish the building potential to overcome this situation adapting to the original use complementary functionalities. Therefore, a delicate reflection to propose new uses for them was especially relevant. In this respect, the paper addresses the idea of optimising public resources and the possible repercussions of multiple actions on the value of authenticity, from a current approach to the rehabilitation of heritage buildings based on the concept of sustainability.

CODE 348**ON ARCHITECTURE FROM THE SECOND HALF OF THE
XX CENTURY IN POLAND****Zychowska Maria J; Andrzej Bialkiewicz**

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e-mail: andrzej.bialkiewicz@pk.edu.pl, web: <http://www.pk.edu.pl>**KEYWORDS:** Contemporary; Cultural; Architecture; Heritage; Architecture.**ABSTRACT**

The principles of protection of contemporary cultural heritage have gained importance over recent years owing to the activities of the European Commission. It is worth recalling that culture has been recognized as the key to building diversity among European societies in the context of changes such as digitization, globalization, increasing social diversity and a changing work environment, which pose a threat to the common cultural policy.

In the European Year of Cultural Heritage 2018 priority was given to joint actions aimed in particular at maintaining the cultural diversity as a legacy passed down from previous generations and as a resource for sustainable cultural, social, environmental and economic development in Europe.

Also recent decades have brought a fashion for interventions to preserve contemporary heritage. Well-known structures of the modern movement across the world, earlier too young to qualify for monument protection, now were perceived need to preserve them. Therefore, actions have been taken primarily to increase public awareness of these unique resources.

This year's Pritzker Prize was awarded to the architects who are also unique in postulating to preserve the existing buildings that can be transformed and thus make permanent what already exists, including the objects erected in the second half of the 20th century.

CODE 366**DETERIORATIONS AND RECOVERY PROJECTS IN THE FORTIFICATIONS OF THE CARIBBEAN COAST OF PANAMA, PORTOBELLO AND SAN LORENZO****Durán, Félix¹; García, Elizabeth²**

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e-mail: egarcia@a3-sa.com, web: www.a3-sa.com**KEYWORDS:** Panama; Restoration; Fortifications; Pathologies; Deterioration.**ABSTRACT**

The Fortifications of the Caribbean Coast of Panama, included since 1980 in the World Heritage list, are an important example of the military architecture of the 17th and 18th centuries. This set of buildings formed by the San Lorenzo el Real de Chagre Castle and the fortifications of the Bay of Portobelo, are part of the vast set of fortifications built in the Caribbean Sea by the Spanish Crown with the aim of defending the transatlantic trade routes during the colonial era.

In 2012, the Fortifications on the Caribbean Coast of Panama were included in the World Heritage in Danger list, mainly due to deterioration caused by lack of maintenance, environmental conditions and, in many cases, uncontrolled urban growth. This has led to the degradation of the structural integrity of the assets and the potential loss of their outstanding universal values.

This document aims to collect the main deteriorations found in the fortifications and the solutions implemented in different intervention projects. Among the monuments studied are the San Fernando battery, the San Jeronimo battery, and the Santiago de la Gloria castle in Portobelo, along with the San Lorenzo castle at the mouth of the Chagres River. Landslides and stone material disintegration, plaster loss, deformations caused by foundation failures, are some of the identified deteriorations in these buildings, and whose study has helped define recovery parameters for this set of military architecture.

Through the analysis of the state of conservation of the fortifications and the classification of the different pathologies that are present in the fortifications, it was possible to find the origin of the problems and define practical actions for the recovery of this heritage complex, operations aimed to restore the structural integrity of the buildings without distorting their heritage image.

CODE 368**VERNACULAR ARCHITECTURE OF QUINGEO PARISH (AZUAY, ECUADOR).
DEFINITION OF THE HISTORICAL-CONSTRUCTIVE CONTEXT FROM THE
MURAL STRATIGRAPHIC ANALYSIS****López Suscal, Michelle*¹; Aguirre Ullauri, María del Cisne²**

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e-mail: cisne2222@hotmail.com, maguirreu@ucacue.edu.ec**KEYWORDS:** Vernacular architecture; Wall stratigraphic analysis; Heritage conservation; Quingeo.**ABSTRACT**

The vernacular architecture of the rural parish of Quingeo in Azuay (Ecuador) comes from a process of community, social, constructive, and cultural appropriation; it derives from the transfer of knowledge and wisdom of its inhabitants inherited from generation to generation. This particular way of construction is manifested as representing a physical, socio-collective, and anthropological environment, which generates community-constructive identity with deep relationships in the landscape. However, despite this favorable context, it has been affected by globalization, contemporaneity, abandonment, inadequate public, economic and social management, and the lack of conservation tools that have caused the extreme deterioration of its heritage condition.

Recognizing this situation promotes the description of the historical-constructive context based on 3 case studies as examples of the architectural heritage of Quingeo and Azuay. Thus, based on the bibliographic analysis, the collection of information through architectural and archaeological forms, structured interviews, and heritage valuation forms, the state of conservation and heritage valuation is defined with social, cultural, and landscape variables. These inputs allow the application of wall stratigraphic analysis to define the historical-constructive sequence and the degradation sequence based on the constructive pathologies to understand the need to conserve and manage heritage buildings.

CODE 372**CONSERVATION AS A DESIGN OPPORTUNITY.
PROTECTION SYSTEMS IN THE ARCHAEOLOGICAL FIELD****Cadoni, Stefano***

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email: stefano_cadoni@tiscali.it, web: https://www.unica.it/unica/it/dip_ingcivile.page**KEYWORDS:** Old-new; Deferred pre-existence; Crossing; Philology; Design.**ABSTRACT**

The contribution explores the theme of contemporary design within archaeology, in particular with regard to in situ conservation and museumization needs.

In situ protection is one of those boundary conditions where it is interesting to define the field of real and potential relationships between the pre-existing and the new. A particularly delicate balancing act emerges which, starting from the excavation work, highlights the need for contemporary design for conserving archaeological sites, not only in terms of performance.

If the baseline objective of protective infrastructures is prevention, the theme concerning taking care of archaeological and historical heritage can identify a fertile intersection with the theme of space and soil re-use, in terms of frequentation and re-appropriation.

Is conservation of material alone effectively the only way to deal with heritage? The question invests the potential of protective devices in terms of design, quality of space, quality of conservation but also of the deep-rootedness and actualisation of the preserved heritage, intended as the assimilation and appropriation in the riverbed of long-lasting processes, which does not lose impetus in a diachronic stratification based exclusively on the distinction of form and language, not always capable of generating an old-new system.

The contribution highlights questions of method concerning the theme about the old-new relationship to identify a potential preliminary approach to the considerations of the case by case, attempting to overcome a rearguard approach, also detectable in the terminology, which still sees design in the archaeological field defined within the limits of provisional protection, sheltering. The key points of this approach are: the peculiarity of archaeological pre-existence in terms of space and time (deferred pre-existence) and fragility; the absence of structured relationships with the place; the interscalarity and multiscalarity of the problem; contemporary design not as a functional subordinate of the pre-existing but as a necessity surpassing the performance framework for the construction and reconstruction of relations of pre-existence with the place and landscape, in which the themes of crossing, analepsis and re-appropriation are decisive; that the development of new virtual reality tools can relieve architecture of the burden of philological simulation of space.

CODE 391**SANTA MARÍA DEL CAMPO AND SANTA MARÍA DE RIOSECO: EVOLUTIVE
CONCORDANCES OF TWO OUTSTANDING CASTILLIAN BELL-TOWERS****Sánchez Rivera, José Ignacio¹; Sáiz Virumbrales, Juan Luis²**1: Departamento de Física Aplicada. GIR “Rodrigo Zamorano de H^a de la Ciencia y de la Tecnología”

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e-mail: juanlsaiz@hotmail.com**KEYWORDS:** Bell-towers; Steeples; Diego de Siloe; Medina de Rioseco; Santa María del Campo.**ABSTRACT**

In Medina de Rioseco (Valladolid) and in Santa María del Campo (Burgos), a monumental couple of towers raise. These towers have important parallelisms and display the transition from Gothic to Renaissance architecture, finishing in a Baroque manner. Both are built over the West-end of their respective churches and, so, both adopt the porch-tower typology. The one in Rioseco, erected about A. D. 1500, collapsed at the beginning of 18th Century and then, it was rebuilt with some respect to its ancient decoration. The one in Santa María del Campo, designed by Diego de Siloé, replaced an older tower whose remains have been discovered by our investigation. Both towers are capped with 18th Century lanterns, updating its image in that era.

On this paper, both towers are analyzed with the aid of new and meticulous 3D architectural plans, which display their masonry allowing a stratigraphic lecture. With these tools, it has been possible to us to discover new and fundamental particulars on these towers, what has let us to establish its architectural evolution. To elaborate the aforementioned architectural plans, we have used a combination of traditional and trendy techniques to generate a computer 3D-matrix with AutoCad, from which we have extracted floor-plans, elevations, sections and different perspective drawings. This type of analysis permits a better understanding of those complex buildings, which is of undeniable importance both to architectural restorations and to divulge to community.

CODE 25

**TWO ICONS OF BILBAO'S INDUSTRIAL HERITAGE:
ETXEBarria'S CHIMNEY AND ZORROZA'S CRANE**

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KEYWORDS: Chimney; Crane; Industrial Heritage; Urban Regeneration.

ABSTRACT

The works developed for the Bilbao City Council are presented in two iconic elements of the industrial heritage, the chimney of Etxebarria and the crane nº 67 of Zorroza.

Chimney of Etxebarria: The chimney, which is located and gives its name to the Park of Etxebarria, is the only survivor of the metallurgical factory that the family of Federico de Echevarría built on the grounds of the Caserío Rekalde, acquired in 1878. Although the chimney that is preserved is not so old, since it was erected in 1943. The factory closed its doors in 1980, and eight years later the facilities were dismantled to make way for the largest park in Bilbao. The chimney, with its 49.90 meters high and its brick structure, remains unmistakable and is a testament today to the industrial development that lived Bilbao long ago.

The Chimney has been subjected to various periodic inspections. At present, it has been considered necessary to carry out a global inspection of the structure, of its general condition and of the evolution of the different pathologies observed over time.

Crane nº 67: Zorroza is one of the popular neighborhoods of Bilbao that has most coexisted with port traffic when it was carried out inside the estuary. And it's also the last one to have had recent port activity.

Soon, the pier of Zorroza will be integrated into the urban public spaces, and the last urban port crane present in the pier of Zorroza, currently owned by the City of Bilbao, aims to be preserved and converted into an icon of the neighborhood and the Villa.

The article contains the scope of the work carried out on both elements, the description of them, the approach and the conduct of the studies carried out, the uniqueness of the results obtained, in order to finally provide general conclusions about the integration of these industrial assets into the Bilbao urban spaces.

CODE 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****Vásquez Fierro, Virginia^{1 2 *}; Horn Morgenstern, Andrés^{1 2}**

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KEYWORDS: Heritage; Rurality; Vulnerability; Typologies.

ABSTRACT

The Valdivia River basin (Los Ríos Region, Chile) is a complex hydrographic system shared between Argentina and Chile, characterized mainly by large mountain lakes and transverse rivers that flow into the Pacific Ocean. The system has a surface area of 12,760 km² and is segmented into five tributary sub-basins, one of which is the San Pedro river basin. During the first half of the 20th century, necessary actions were concentrated there that allowed a sustained expansion of the productive areas towards the interior valleys through intensive exploitation of forestry and livestock activities. It was possible due to the systematic introduction of the steam engine in its various formats, increasing efficiency and production volumes and becoming the region's most important economic sector. This growing productive activity originated the demand for the construction of new buildings for various purposes and uses, for example, housing for landowners and tenants, storage warehouses, and complementary facilities to adequately respond to the increase in production. Consequently, it is configuring a unique typology of productive rural complexes intertwined with their biophysical matrix and articulated in a territorial system. Over time, changes in the effective model and the irruption of global trade forced the undesirability of its uses, the gradual loss of functionality and the abandonment of the original destination. Therefore, defining a progressive state of vulnerability in the social, environmental and material dimensions. In this context, the demand for anthropic risk and fragility to which the assets are exposed is fundamental, especially when incorporating as a variable the seismic danger that is inherent and constantly models the territory under study.

In the face of this scenario and the elevated levels of current deterioration, it is still possible to recognize a persistent expression of local identity and a particular way of living associated with the territory in these architectural ensembles. The antecedents mentioned have motivated the elaboration -still under development- of a multidimensional analysis model. It provides a proper patrimonial valuation of these rural production systems. It considers particular and local attributes and the projective evaluation of their levels of validity and adaptability to current scenarios, being this article an advance of the results of the first stages of research. The results will allow a preliminary characterization of these groups' states of heritage vulnerability in the American and southern contexts.

CODE 103**JESUIT RANCHES HERITAGE OF NUEVA ANDALUCÍA AND TERRITORY
ARTICULATION. A CASE FOR MANAGEMENT, PRESERVATION AND
REACTIVATION**

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KEYWORDS: Jesuit ranches; Nueva Andalucía territory; Royal roads; Heritage management and technology.

ABSTRACT

This work addresses the study of Spanish-American heritage in 17th century Jesuit ranches in Córdoba of Nueva Andalucía, and their territory articulation, with reference to Andalusian counterparts.

We aim to evaluate the development of the settlements, the heritage continuity from the Hispanic peninsular aspect, vernacular cultural elements in their implant and the characterization of the support environment. We seek to research into management mechanisms to reactivate the objects of study and their territory. We used a mixed methodology with studies of: comparative historical patterns of peninsular and American territories; founding backgrounds; territorial analysis through GIS systems; comparative studies of Jesuit establishments in Europe and America; productive systems of Jesuit haciendas and estancias; and resulting architectural developments. Finally, the heritage significance to date, with an understanding of Jesuit decadence factors, is analysed.

The large Jesuit territory in Córdoba of Nueva Andalucía [today Argentina] controlled the South American hinterland as geopolitical hub through which passengers and merchandise crossed on the Potosí - Buenos Aires route, and towards Lima, Guayrá and Chile, where the Society of Jesus was. The conditions of the region replicated those of Andalusia and became a familiar framework for the conquerors, who were native of that region. The territory additionally met the conditions sought by the Jesuit fathers for their foundations.

The Jesuit settlements followed the Crown's policies regarding evangelization of indigenous peoples but were also based on objectives of territorial occupation and liaison with European centres [Seville, Sanlúcar de Barrameda, Cádiz, etc.].

Jesuit heritage, nowadays recognized by UNESCO, is essentially monumental. However, the importance of the supporting territory, plus the cultural landscape, essential items of the heritage baggage, need to be valued, listed and catalogued. A rational structuring of these heritage elements within an updated management framework would allow more rigorous and profound actions for future conservation and reactivation.

CODE 111**THE SAN TELMO BRIDGE IN SEVILLE. A PIONEERING WORK IN
REINFORCED CONCRETE AT THE BEGINNING OF THE 20TH CENTURY**

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KEYWORDS: San Telmo Bridge; Reinforced concrete structure without falsework; Pneumatic concrete caisson foundations.

ABSTRACT

In 1920, the Spanish Government invited tenders for the design and construction of a new bridge in Seville, to be called Puente de San Telmo, for which a preliminary design was requested for a 3-span bridge, the central drawbridge, to allow maritime traffic to reach the Isabel II Bridge. The winner of the competition was José Eugenio Ribera, perhaps the most prominent Spanish engineer of his time, who incorporated into his team the young engineers Torroja and Entrecanales, who brought their youth and training to the project.

The existence of the Revista de Obras Públicas since 1853 makes it an invaluable archive from which to analyse the engineering works carried out over more than a century and a half in our country, providing privileged information on the world of Spanish engineering.

The San Telmo Bridge is analysed in the pages of the ROP by its authors, who describe the construction of the two lateral sections of the bridge using the mixed iron and concrete structure system, built without falsework, while the foundations of the bridge were built using reinforced concrete pneumatic caissons, the first example of foundations built in Spain using pneumatic caissons of this material.

The aim of our research is to disseminate the built heritage, structuring the work by means of a methodology based on the compilation of information and documentation and the study of the historical and technical background, the contribution of considerations on the project and the analysis of the construction systems used, obtaining as an added result the enhancement of the construction systems used, with an impact for the time.

CODE 121**FROM THE CATALAN MASIA TO THE MASSERIA OF SOUTHERN ITALY:
PATHS FOR THE RECOVERY AND REUSE OF RURAL ASSETS IN
BASILICATA****Guida, Antonella¹; Porcari, Vito Domenico²; Andrulli, Giovanna^{3*}**

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KEYWORDS: Protection of the architectural heritage; Guidelines for recovery and reuse; Masseria; Masia.

ABSTRACT

The significant moment of the act of restoration is the knowledge of the existing. The protection and enhancement of the historic city takes place through the interpretation of its constituent elements and the surrounding territory. In the dynamic complexity, coherence and integration of human and natural processes that characterize the landscape, it is necessary to promote dialogue between the city, which has become the central territory of the most significant social dynamics, and the rural areas, which are mainly considered as marginal territory. The neglect of the rural heritage leads to its irreparable degradation or compromise, even after restoration, expansion or change of use that is incompatible with the identity of the building and the landscape that hosts it. Rural buildings represent the emblem of an ancient anthropisation of the territory, revealing in the architectural and functional typology of the buildings and in the management of the pertinent spaces the economic, political and social condition of the rural-pastoral civilization. Different areas of the Mediterranean reveal interrelational links that associate social and territorial dynamics: from the masseria in southern Italy to the Catalan "masia", a link can be seen in the typological-functional structure changed in the material and construction technique typical of the place. From tower-houses to fortified farms, from the "torchis" technique with a wooden structure to structures in tuff stone and lime mortar, the connection between the forms of architecture and the surrounding landscape emerges. In the same way as Catalonia's experience with the implementation of the "Special Plan for the Catalogue of Masias", the "Guidelines for the recovery and reuse of rural assets in Basilicata" have been experimentally defined, in terms of method and content, and subsequently applied to a case study, proposing a recovery model based on knowledge, conservation, use and promotion of the traditional architectural heritage of Basilicata. The intention is to shed light on the problem of reuse and destinations compatible with the architectural, constructional and bioclimatic characteristics of the artefacts and their landscape surroundings, as well as the control of traditional and innovative construction techniques for the appropriate management of these assets.

CODE 126**CHARACTERIZATION OF NATIVE SHUAR ARCHITECTURE:
ARCHITECTURAL TYPES, REPRESENTATIVE ELEMENTS AND
CONSTRUCTION SYSTEMS****Soto Toledo, Katherine Haydee^{1*}; Rodríguez Torres, María José²**

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e.mail: mariajoc-z@hotmail.com, web: <http://www.utpl.edu.ec>**KEYWORDS:** Territory; Heritage; Shuar community; Native architecture.**ABSTRACT**

The Shuar community is located in the interior territory of the Amazon of Ecuador; becoming one of the most important living cultural manifestations in the region due to the high sense of heritage given by the survival of knowledge and customs in their way of living transmitted from generation to generation. Currently its habitat and its cultural legacy is seriously threatened by territorial extractive activities.

This research focuses on native Shuar architecture; The objective is to determine architectural typologies, representative elements and construction systems through anthropometric analysis, knowledge and customs that survive in the community in relation to the characteristics of the territory for the identification of production systems, raw materials and quarries. The methodology proposed for the architectural analysis is based on comparative cards and matrices between Static anthropometry and Shuar anthropometry, in order to establish similarities and differences between these two systems applied to spatial processes and architectural elements. Likewise, traditional construction processes are analyzed and documented.

The result establishes an architecture with anthropological features and a high sense of place; whose characteristics are applied as transfer elements in the proposal of the so-called interpretation infrastructures as architectural conceptions that determine the heritage value of the community's way of living.

CODE 127**19TH CENTURY MERSIN COMMERCIAL BUILDINGS, PRESENT
CONDITIONS, AND PROBLEMS OF CONSERVATION****Darendeli, Tuğçe^{1*}; Umar, Nur²**

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e-mail: numar@atu.edu.tr, web: <https://adanabtu.academia.edu/NurUmar>**KEYWORDS:** Mersin; 19th Century; Commercial Buildings; Conservation; Documentation.**ABSTRACT**

Mersin, located to the south of Turkey's Anatolian peninsula, is a city which has hosted many civilizations throughout history, remaining under the dominance of the Hittite, Assyrian, Iranian, Greek, Roman, Byzantine and Ottoman civilizations. The city, after losing importance in the medieval period, starts developing with the impact of changes the Ottoman Empire experiences during the 19th century after the Tanzimat period.

Mersin, being a small coastal village in Middle Ages, became an important port city of the Mediterranean with the commercial and financial activities of the 19th century. As a result of commercial activities in the region, wealthy Muslim, non-Muslim and Levantine families started to migrate in. This gave the city a more cosmopolitan look. Apart from Levantines in the city, there are Maronites, Arabs, Greeks and Armenians, Jews, and a small number of Chaldean, Assyrian and other non-Muslim communities from around Aleppo.

The development of commercial life, the growth of the port and the architectural activities in the city all went hand in hand. Many new neighborhoods were established in the city close to the port. Warehouses, factories, banks, inns, hotels, stores and shops began to open in these neighborhoods. Neighborhoods established in a grid system parallel to the sea and the port enabled the city to develop on the east-west axis. Especially, the Uray Street, which is close to the port and customs, has acted the most intense and active line in the commercial life. Commercial activities were also taken to the streets parallel and close to the Uray Street.

The aim of this study is to examine the causes and consequences of the changes Mersin has gone throughout the 19th century. It aims to study the architecture and history of new building types which emerged as a result of the intense commercial activities of this period. Especially, the structures which were built in the 19th century will be determined on site and their current status and conservation problems will be examined. Finally, solution proposals will be produced for the conservation problems of the structures determined by the field studies.

CODE 135**DEVELOPMENT LINE OF THE RESIDENTIAL ARCHITECTURE OF THE
ISLAND OF SAN CRISTÓBAL-GALÁPAGOS: THE CHALLENGE OF
OFFERING VERNACULAR ECOLOGICAL SOLUTIONS****Matapuncho-Davila, Elvira^{1*}; Granda-Viñan, Paola²; Aguirre-Maldonado, Eduardo³**

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e-mail: ebaguirre@utpl.edu.ec, web: <https://orcid.org/0000-0002-7911-008X>**KEYWORDS:** Galapagos Islands; Vernacular architecture; Historical analysis; Typological study.**ABSTRACT**

Vernacular architecture as a functional response to the environment, acquires unique nuances through cultural values shaped by a long process based on a prolonged settlement. Besides it offers technological and formal solutions that endure as tradition. The new settlements generally propose building solutions based on technologies brought from other latitudes where they have been perfected and modified over the years to adapt and show belonging to the site; they propose unique and very effective solutions for the environment and its climate. However, when the implementation of the construction technique becomes highly dependent on other urban centers that provide materials, labor and knowledge, in this case, the architecture can not fully integrate into the environment and may constitute a problem when it begins to spread into natural areas with a unique ecological wealth. For instance, the island of San Cristóbal in Galapagos-Ecuador exhibits this problema due to its historical dependence on the administrative center of the country (Ecuador). At the present time, the city is expanding in terms of housing as a result of accelerated tourism growth in the last decades of the 20th century. In this regard, in addition to the concern about how housing growth influences the surrounding ecological development, this work similarly raises the problem of how housing with a vernacular character should be developed in the new urban and architectural planning for the following decades. Therefore the present study analyzes and reconstructs the development line of the different housing typologies implanted on the island of San Cristóbal in the middle of the 20th century; recognizing through historical documents and virtual reconstructions the way in which forms and constructive technologies are related to the environment. At the same time, this work proposes the search for original characteristics of this architecture with the potential to be revalued as lessons in vernacular architecture.

CODE 144**CANTONA: THE URBAN ARCHEOLOGICAL HERITAGE, AS AN ANALYTICAL PATH TO RECONCEPTUALIZE THE SOCIAL PRODUCTION OF THE HABITAT****Álvarez, María del Pilar^{1*}; Nava, José María Wildford^{2*}**

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KEYWORDS: Territory; Archeology; Urban fabric; Housing; Production; Social; Habitat.

ABSTRACT

Ignored, although not unknown, the Archaeological Site of Cantona is presented as an intriguing apparition that forces us to reformulate to a large extent, an important part of the Classic and Epiclassic periods in the history of Mesoamerica. Located in Mexico, specifically northeast of the State of Puebla; the fact of being far away from the large urban centers from the Viceregal and Independent periods, generated that, although registered, it was not considered as a formal study site until 30 years ago.

What was discovered from the archaeological clearing (today it reaches less than 2% of its extension) was a very complex urban network, where a stone walled acropolis stands out, woven by multiple ceremonial centers among which 25 ballcourts stand out - the largest number of these structures found in a Mesoamerican city so far - and showing a surprising diversity of social composition among its inhabitants.

Unlike any other large urban center of the Classic Period, where the physical record of the common population housing areas has been lost, the city of Cantona, hidden behind a mountain occupied by an atypical forest of yuccas and pines and settled on an igneous rock ground from which the stone that configures its structures is obtained, the housing footprint has survived. Its study allows us to understand how a large city was able to survive several centuries being a commercial and cultural exchange center, as a result of integrating within its urban fabric a complex housing system that allowed artisanal and agricultural production, and housing enclosures for the religious and political elite class. All the above was surrounded by hundreds of popular housing neighborhoods without disassociating them from the great city.

In this article, we will analyze one of the cleared sectors of the city, where the common housing is located; we will conclude with a critical reflection that allows us to recover the ancestral lost knowledge, where the study of the heritage and its territory becomes part of a strategy to establish new alternatives that lead us to the social production of habitat.

CODE 217

EVALUATION OF PROPOSAL FOR THE CONNECTION OF ARCHITECTURAL HERITAGE AREAS. CASE STUDY: MANIZALES, COLOMBIA

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KEYWORDS: Sustainable mobility; Accessibility; Protection; Conservation; Architectural heritage.

ABSTRACT

Heritage and cultural development face important challenges related to the application of conservation and preservation models. On the other hand, current urban planning methodologies are based on the application of sustainable mobility principles that seek to discourage the use of motor vehicles, in order to minimize possible negative impacts on historic and protected areas. The case study is located in the city of Manizales (Colombia), where the main Central Business District (CBD) are two sectors officially declared as protected heritage, the historic center and the La Camelia - Torre de Herveo Cable Car Station. This research proposes the insertion of active mobility infrastructures, supported by an adequate articulation of the mobility conditions and urban structure, assessing the impact of the proposal through the application of an analysis of urban territorial accessibility. The goal is to demonstrate that through the application of geostatistics and geospatial analysis is possible to implement protection strategies for these sectors without the need to deteriorate the current accessibility conditions of other existing modes of transport. The evaluation of the insertion impact of active mobility infrastructures is analyzed in relation to socioeconomic and sociodemographic variables by comparing the coverage that would occur in the current scenario and the future scenario. All the above requires a detailed analysis of the relationship between transport management policies and the spatial distribution of activities, specifically seeking to improve the relationship between the community and the conservation of these heritage areas.

CODE 275**FENCE WALLS IN THE BAIXO TÂMEGA VALLEY****Pinto, Jorge¹; Reis, Cristina²; Bento, Ricardo²; Bentes, Isabel¹; Pereira, Sandra¹**

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e-mail: crisreis@utad.pt, rbento@utad.pt**KEYWORDS:** Pathology; Heritage; Traditional constructive solutions; Rural area.**ABSTRACT**

Using a fence to limit property physically is a recurrent constructive solution in Portugal. This reality applies to constructing a single-family house, industrial plot, agricultural land, highway, or railway, among other possibilities. The fence structure can be very varied, and the municipal rules for this purpose are not always detailed and uniform. This work intends to briefly reflect this theme in the case of the Baixo Tâmega valley, Portugal. A survey of the different solutions applied and an analysis of the impact of these constructive elements on the green wine vineyard landscape will be some of the results we intend to share. Emphasis will be given to traditional fencing solutions applied in this region to enhance them. It is believed that what is exposed in this document can contribute to preserving the landscape in an area that is a public good. The lessons drawn here could be warning clues for possible future damage of this type of public good in other regions. It is essential to highlight that this paper presents the first results of more extended research work concerning this topic.

CODE 284**EUROPEAN SMART VILLAGES: STATE OF THE ART AND POSSIBLE
DEVELOPMENT SCENARIOS****D'Andria, Emanuela^{1*}; Fiore, Pierfrancesco¹; Falce, Carmelo¹**

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email: emdandria@unisa.itemail: pfiore@unisa.itemail: cfalce@unisa.it**KEYWORDS:** Smart Villages; Small Mediterranean towns; Inland areas; Recovery and valorization.**ABSTRACT**

The depopulation of small Municipalities in inland areas is a complex phenomenon that has significant repercussions both in the socio-economic field and in the protection of an important tangible and intangible heritage. The 'marginalisation' of some territories is a prerogative of many Countries, not just Italy, and the causes of demographic decline are mainly to be found in the lack of job opportunities, inadequate infrastructure and the general shortage of efficient services (education, health, transport). However, these realities preserve age-old knowledge, ancient traditions, typical production activities, material and immaterial assets of considerable value, as well as a precious architectural, landscape and natural heritage.

In the last decade, as the environmental crisis has progressed, there has been an awareness of small settlements' potentials, supported by the idea that their regeneration could promote sustainable development. Re-inhabiting inland areas would reduce not only land consumption, but also urban congestion and air pollution, and encourage healthier and more balanced lifestyles.

For these reasons, many strategies have been developed both at national and international level in order to tackle depopulation. Among these, of considerable interest is the European Smart Villages approach, based mainly on the use of digital technologies to reduce the economic and social gap between the city and the widespread territory.

In the light of the above, starting from an analysis of the state of the art, the paper investigates the Smart Village initiative, focusing on its main criticalities and potentials, with the aim of highlighting possible developments. In fact, to date, the model is calibrated on the rural areas of North Europe and needs to be upgraded in order to preserve the many different characteristics that distinguish other geographical realities, such as climate, culture, social and economic factors. It is a matter of recalibrating the model and making it more flexible, also considering current changes and what can be foreseen in a future scenario. Therefore, the paper proposes a reinterpretation of the model aimed at implementing its intervention criteria in order to adapt it to Mediterranean Countries, which have very different peculiarities and criticalities from those of northern European rural areas.

CODE 292**TRANSFERENCE FROM INDUSTRIAL ARCHITECTURE TO RESIDENTIAL BUILDINGS: REYES CATÓLICOS STREET DURING THE EXPANSION OF THE SUGAR INDUSTRY IN GRANADA AS A CASE STUDY**

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KEYWORDS: Eclectic residential architecture; Industrial architecture vs residential architecture in the 19th century; Constructive systems; Rental properties.

ABSTRACT

As a direct consequence of the expansion of the sugar industry, the context in which the city of Granada had settled shifted notoriously in the late 19th century. Rental properties were now built with the sole purpose of being used as residential buildings, a model that had been borrowed from the Eclecticism that had previously taken over European architecture. Its development was executed by several architects that, likewise, actively participated in the construction of sugar factories and other types of factories linked to the production of sugar between 1882 and 1891.

Using the in-depth analysis of the architectural and constructive characterization of these models as a foundation, the main goal behind this study is to record and demonstrate the technical transference of the systems used in the construction of factories into the eclectic residential model that was being introduced. Our main focus, in this case, would be Reyes Católicos street, one of the different sections of what is known as the “corridor street”, which establishes the axis around which the city center of Granada developed. Said street connects Gran Vía de Colón street with the urban area of Puerta Real, where five different streets intersect: Reyes Católicos, Recogidas, Ganivet, Mesones, Acera del Darro and Acera del Casino.

After conducting an exhaustive record of the constructive systems used in both, our study has led us to draw a few interesting conclusions about the already proven transference of the constructive systems used by industrial architecture and the ones used in the residential buildings that were built back then.

CODE 316**EARLY REPUBLIC PERIOD MALATYA STATION BUILDINGS****Sarı, Fatma Zehra^{1*}; Umar, Nur²**

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KEYWORDS: Malatya; Train Station; Railway; Early Republic.

ABSTRACT

With the industrial revolution, important developments in world history have occurred. Railway transportation, which was an important technological development of the period, brought along many economic and political developments. This development was also reflected in urban areas and architecture to a large extent. This technological development that emerged in the 19th century caused the formation of station buildings, as a new building type. The Ottoman Empire, which did not have the financial and economic structure to realize the new transportation system as opposed to the rapidly developing West, transferred the construction and operation of the railway to foreign operators. The transportation network in the hands of foreign companies led to practices countering Ottoman interests. Railways and train stations the independent Republic of Turkey inherited from the Ottoman Empire are the reflection of the modernization approach of the country in the Early Republican Period. In this context, the station buildings, telling about the historical process of the period in which they were built, became the language of the city for that particular period.

Malatya, one of the eastern provinces of Turkey has been the gateway and crossroads of Anatolia and the Middle East since the ancient times. The oldest transportation route in the East; is the road that connects Erzurum via Malatya & Sivas and from there leads to the Caucasus. Being located at a junction point for transportation, Malatya has also become one of the most important centres for railway transportation in Anatolia. In this study, the station buildings in the province of Malatya, which were built in the early years of the Republic will be determined and their brief descriptions will be given. The aim is to examine the architectural features of the determined station structures in terms of plan, façade, ornament, style, construction technique, and preservation status in periodical integrity and to contribute to other researchers by creating a catalogue.

CODE 394**THE RECONSTRUCTION OF ZIKUÑAGA CHAPEL OF HERNANI:
BUILT HERITAGE LOST AND FOUND****Uranga, Eneko J.¹; Arraztio, Xabier; Uranga, Juan José**

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KEYWORDS: Zikuñaga; Chapel; Heritage; Built; Reconstruction.**ABSTRACT**

The Virgin of Zikuñaga and the Chapel of the same name first written documents date back from the 16th century. After a long life as the supporting reference of the Urumea valley, the Chapel began the process to become a Historic Monument in 1975. This process did not prevent it from being demolished almost twelve years later, in 1987. The Papelera Guipuzcoana de Zikuñaga paper mill purchased the land to the bishopric of San Sebastian on which the chapel stood until the 1970s. This economic operation led to its dismantling. The agreement envisaged the obligation of rebuilding the chapel elsewhere, but this did never happen. Deeply rooted in the conscience and religiosity of the citizens, the disappearance of the Chapel caused great upheaval among the neighbours, as well as a great loss for the Basque cultural heritage.

Nearly 30 years passed before the commitment to rebuild the Chapel was taken up again in 2016. The basis of the reconstruction was the ashlar guarded by the paper industry during this time. The Provincial Council of Gipuzkoa had considered the Chapel reconstruction as to be of Public Interest, and Hernani Town Council approved the file for this work. A building is projected with the construction of the main historic façade, but because only part of the original construction is available, a new architectural design is made.

The aim of this communication is to report on the fact of the near disappearance of a historic building that is part of the built heritage; how the process of dismantling and storing the constructive elements took place; and the methodology used for its reconstruction. But in addition to showing the reconstruction criteria that have been used, the target is to reflect on the decision-making process for the reconstruction of the built heritage when it is incomplete, and how it can be projected into the future through contemporary action.

CODE 11**MORE THAN A GREEN FAÇADE: THE GREEN POTENTIAL
FOR HISTORIC CENTRES****Vallejo Espinosa, Andrea^{1,2}; Davis, Michael Maks^{1,3}; Ramírez Cevallos, Francisco¹**

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e-mail: davismaks@evolutionecoengine.comweb: <https://www.evolutionecoengine.com>**KEYWORDS:** Historic centres; Green façade; Green densification; Green city; Biophilia.**ABSTRACT**

The historic centre of Quito is a patrimonial nucleus designed in the colonial era. It maintains a high construction density with 80% built up area and 20% complementary spaces, where green areas cannot be included. The lack of green area is a problem in the compact city, since it enhances the incidence of environmental problems that affect the health and comfort of its inhabitants. For this reason, the present research explores the concept of vertical urban gardens and the potential to increase green areas in densely built up historical centres. The aim is to explore existing opportunities to incorporate vertical greenery in patrimonial centres that suffer from a sufficient green space. An urban analysis was performed, following the Gestalt perceptual laws that allows a graphic classification of spaces. A combined methodology of mapping and fieldwork research, vertical spaces with potential for incorporation of vertical gardens were identified. The spaces represent a potential addition of 38% to the green areas that currently exist. This incorporation has the advantage of having a minimal impact on the existing space and being a positive aesthetic addition for the historic centre of the city.

CODE 45**BUILDING AND URBAN CHARACTERISTICS FOR THE DEVELOPMENT OF INTERVENTION STRATEGIES IN THE PONTE GÊA NEIGHBORHOOD OF BEIRA****Santos, Michael M.^{1*}; Ferreira, Ana Vaz²; Lanzinha, João C. G.³**

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KEYWORDS: Urban characterization; Constructive characterization; Rehabilitation; Built heritage; Climate change; Beira, Mozambique.

ABSTRACT

This paper addresses the constructive characterization and urban morphology of the neighborhood of Ponte Gêa in the city of Beira in Mozambique. The Ponte Gêa neighborhood extends over approximately 275 hectares and has a population of approximately 25,803 inhabitants according to the 2017 census in approximately 3300 homes. The implementation of strategies for the protection and revitalization of our historical and architectural heritage is fundamental for preserving cultural identity and improving user comfort. In this sense, we present a synthesis of the main typologies, construction techniques, and urban structure as a starting point for the proposal of strategies and urban intervention plans that aim to improve the energy and water efficiency of the built stock and mitigate the risk of climate change, namely, recent storm and flooding events that violently impacted the city. For the general characterization of the buildings, survey sheets were used to address questions such as the age of construction, state of conservation, geometry of the buildings, types and materials used in exterior walls and roofs, type of glazing, solar protection devices, cooling equipment, energy sources, supply, and storage of drinking water and sewage systems were addressed. For urban characterization and coastal erosion, the evolution from the last 17 years was used. Thus, in-depth knowledge of the characteristics of urban spaces and buildings allows the search for urban intervention strategies and plans that aim to establish guidelines for neighborhood renewal.

CODE 58**THOUGHTS ON PUBLIC SPACE. PROPOSALS FOR THE NEW SQUARE OF THE CHURCH OF SAINT ANTHONY OF PADUA IN THE VILLAGE OF NOVENTANA, ITALY****Pietrogrande, Enrico^{1*}; Dalla Caneva, Alessandro²**

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KEYWORDS: Identity; Memories; Urban form; Urban setting; Urban place.

ABSTRACT

This work concerns Noventana, a village located in the Veneto region, Italy, and it specifically refers to the Church of Saint Anthony of Padua. The idea of restoring the central area of the village where the Church stands has long been the object of discussion on the part of local authorities.

The village of Noventana is one of the subjects recently investigated by our students at the 'Architectural and Urban Composition 2' course taught on the master's degree in Architectural Engineering at the Department of Civil, Environmental and Architectural Engineering of the University of Padua. The working method is based on the belief that, in the study of urban morphology, is basic to analyse the history of the city, clarifying the relationship between permanent structures on the one hand and temporary ones on the other. The history becomes an indispensable tool to know the deep reasons of the urban structure which is the memory and the image of the community. The methodology looks at the city as a product of functional systems (political, social, economic), but overall contemplates the urban form as a result of its spatial structure. The life of the urban form is investigated in its physical specificity, the only one able of giving reason of its special nature over every social, economic and political aspect. The centre of the village of Noventana was thought by our students as an opportunity to configure the unity of this symbolic and representative place.

CODE 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****Horn, Andrés^{1,2*}; Vásquez, Virginia^{1,2}**

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web: <https://www.rina.cl/>**KEYWORDS:** Territory; Planning; Decentralisation; Urban wetland.**ABSTRACT**

In Chile, the legislative and normative tradition regarding Territorial Planning Instruments (IPT) in force since 1976 has been characterised by a centralised and hierarchical model, promoting homogeneous definitions and applications in the territory, thus avoiding distinctions and singularities present in the diverse existing cultural and social environments, leaving few tools for decision-making in these matters to local and regional administrations. Since 2001, a change has been announced through the decree of a decentralisation law on territorial planning (DFL 1/19.65, General Secretariat of the Presidency), for encouraging the process of transferring competencies in the political, fiscal and regulatory spheres in order to project the increase of capacities and the continuous improvement of tools in the framework of the extension of local governments' attributions.

In this context, it is therefore desirable to consider regional territorial attributes (productive, social and environmental) as sufficient inputs, adapting and adjusting the available instruments, favouring an appropriate design and sustainable territorial management, with a high social validation and driving local developments.

Although the process is underway, the experiences are still incipient, allowing a critical review of the proposed model. The Master's Degree in Design of Sustainable Environments at the Universidad Austral de Chile - a professional programme with a profile of regional commitment and effective collaboration with local actors - has proposed to empirically evaluate the dichotomy between centralised regulations and their applicability in fragile regional urban environments, allowing us to prospect scenarios of adaptation and adjustments in favour of balanced and sustainable urban growth as a response to the scenario described.

For the above, a review of 3 case studies is presented that consider a situated analysis of urban wetlands in the cities of Temuco and Valdivia; preliminarily, phenomena of the destruction of urban wetland ecosystems are observed, demonstrating the rigidity of the Territorial Planning Instruments in force and the inconsistency between the different levels and actors involved.

CODE 77**SOCIO-TERRITORIAL CONTEXTUALIZATION OF HERITAGE ON INTRA-URBAN SCALE. THE CURRENT HORIZON OF THE MOST RELEVANT OFFICIAL SOURCES****Usobiaga, Elena¹; De Cos, Olga²**

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e-mail: olga.decos@unican.es, web: <https://web.unican.es/>**KEYWORDS:** 2021 Census; GIS; Cadastre; Intraurban research.**ABSTRACT**

Heritage is not an isolated element. It is part of a spatial and social context which affects it and with which it interacts, to the point of needing society to survive. Likewise, heritage represents a key element for social, cultural, and economic regeneration. However, its study from social and territorial point of view is often affected for the availability of information sources at intra-urban scale. This fact conditions both the possibility of knowing the type of heritage and its preservation status, as well as understanding its socio-territorial environment, based on the analysis of their inhabitants and its social and economic conditions.

On this basis, the main objective of this study is to review the different available sources of information to analyse the social and territorial context of heritage elements on intra-urban scale. To do this, an in-depth analysis is made of the two most relevant official sources available in Spain: the population and housing Census and the Cadastre. The study focuses on a prospective theoretical-methodological vision, taking as a starting point the effect that the 2011 Census had on research at intra-urban level in general, and on heritage issues in particular. The study continues analysing the challenges and opportunities presented by the scenario that arises with the 2021 Census draft. All this, approached with a methodological GIS based conceptualization of the territory, systematizing diverse and interrelated information based on its spatial and thematic components linked to heritage elements. But also integrating other superimposed elements, reproducing the interactions of the heritage elements with its environment. In short, the work will provide a systematic view of the sources that would enable various case studies on the subject matter at hand.

CODE 106**GLOBAL ARCHITECTURE: REHABILITATION AND REGENERATION****Vitrano, Rosa Maria**

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e-mail: rosamaria.vitrano@unipa.itweb: <https://www.unipa.it/persone/docenti/v/rosamaria.vitrano>**KEYWORDS:** Urban regeneration; Rehabilitation projects; Built environment; Co-design.**ABSTRACT**

Using architecture as a "global phenomenon", holistically integrating solutions inspired by new scientific progress in the field of urban ecology, is a proactive way of responding to the challenges and precariousness of the contemporary city. In this paper, which illustrates a process of building and urban regeneration developed within the framework of the agreement between the University of Palermo and CICOP "International Centre for the Conservation of Heritage" with the research entitled "G.A. Transition&Regeneration"*, it is necessary to evaluate all the opportunities and benefits that the inclusion of green spaces and lungs bring to building contexts in a perspective of eco-sustainability (green globes) and social inclusion. This also means creating models of rehabilitation and regeneration in a logic of co-design.

With this in mind, the research aims to propose new theories of "global architecture" through which to rebalance the environmental system of cities and individual housing units. These theories form the basis of a reform of living aimed at the wellbeing of citizens and the entire planet, which several European capitals are already promoting in a perspective of ecological transition. It is necessary to start by humanising and "parching" cities, creating new urban metabolisms, developing an integrated design approach which, through innovative and inclusive processes, encourages the triggering of urban regeneration interventions from large to small scale. The results will be calculated on the basis of improvements in living space and citizens' health that will gradually lead us from the Anthropocene Era to the Salutogenic Era.

CODE 299**MANAGEMENT MODELS FOR ENERGY REGENERATION IN URBAN AND RURAL AREAS OF NAVARRA****Izcue, Isabel¹; García Madruga, Carolina²**

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KEYWORDS: Urban regeneration; Housing energy rehabilitation; Energy transition; Urban decarbonization; Climate change.

ABSTRACT

Climate Change and Energy Regeneration are two closely related aspects, so only from a comprehensive and coordinated perspective response will be possible to achieve the great current environmental, social and economic challenges. In Navarra, 36% of the houses were built between 1950 and 1980 (social housing neighbourhoods), which means a total of 115,000 houses. All these homes, as well as their surrounding areas or neighborhoods where they are located, must be rehabilitated to achieve a fair energy transition, which will make it possible to contribute to a carbon-neutral city model by 2050.

This article develops firstly a brief introduction on the context of the energetic rehabilitation of Navarra. The central part of the article is aimed at the definition and description of each of the Management Models through which the implementation of an Energy Regeneration strategy at the regional level is sought. Through these Management Models, it is intended to promote a municipal policy that responds to the real needs of the built environments of Navarra region, based on their physical and socioeconomic characteristics, as well as the climate scenarios proposed in the LIFE IP NADAPTA project. Prior to the characterization and description of the different models, the diagnosis of the socio-urban vulnerability of Navarra for the different types of built environments is briefly explained, in order to identify the potential for regeneration and rehabilitation of the social housing heritage. After having characterized and quantified the rehabilitation objectives, and in accordance with the regulatory and organizational context of the Comunidad Foral of Navarra, it was possible to define the most appropriate management models for each building typology and each social reality.

CODE 369**THE HOUSING HARDSHIP IN ROME. PUBLIC RESIDENTIAL BUILDING VS SOCIAL HOUSING?****Crupi, Francesco¹**

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KEYWORDS: Housing hardship; Social housing; Urban regeneration; Urban welfare.

ABSTRACT

In recent years, the issue of housing hardship has reached levels, and taken on forms, comparable to those recorded in the sixties and the seventies. Since 2007, the domino effect of the financial-sector crisis, which quickly extended to the economy as a whole, and then became a pressing social problem, has heightened the demand for social housing, both in terms of emergency accommodations and in the so-called “grey area”. The Covid-19 pandemic exacerbated the situation, generating still more dire statistics. And yet, while in earlier decades the housing emergency was caused by a structural shortage in the stock of residential units, today the primary problem lies in the procedures dictated by the market for obtaining a home. Any study of housing hardship in the current scenario of climate change, a socio-health crisis and economic recession calls for strategies and tools able to lead to new models for restoring urban and territorial balance, as well as new housing policies, making it a field of research teeming with different theoretical, experimental and propositional perspectives. The paper, having first established the overall reference framework, sets out to illustrate the particular features of the “Rome dossier”, examining the regulatory, procedural, methodological and operational approaches taken over the last 25 years by the various city administrations, so as to highlight not only limits and obstacles, but also paths of ongoing development potentially able to mitigate housing hardship while furthering the complex process of urban renewal.

CODE 370**AUGMENTED ARCHITECTURE AND MULTIFUNCTIONAL BUILDING
EXOSKELETONS, A LOOK AT THE FUTURE OF EXISTING BUILDINGS IN
URBAN AREAS**

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KEYWORDS: Building exoskeletons; Multifunctional exoskeletons; Urban Regeneration; Building Safety and Sustainability; Structural upgrading.

ABSTRACT

The scientific debate in construction is being focused by the increasing demand of reliable and effective intervention both on stand-alone buildings and entire urban neighbourhoods with the perspective of promoting their reuse and refurbishment. Furthermore, a sensitization towards the enhancement of Architectural Heritage has allowed the development of methodologies and international guidelines for the material compatibility of solutions to be applied in the building safety and urban enhancement as a whole. This new awareness of heritage applies both at the scale of the historical cities and of the landscape as recalled by “project actions” in the Mediterranean Europe - rehabilitation or new construction - whose principles of heritage enhancement refer to a territorial dimension. This is the general framework of the Urban Regeneration aimed at the optimization of environmental resources thanks to the containment of land consumption for new buildings. In such a context, the rehabilitation of structures by means of exoskeletons shows the peculiarity of affirming itself in the city fabric with formal and constructive autonomy, overlapping and sometimes opposing to the object to be rehabilitated.

In the present contribution, a critical review of design references and literature is reported; it is aimed at identifying new opportunities in urban regeneration associated with such a class of interventions, starting from the architectural aspects up to technological ones. Finally, the exoskeleton-based intervention will be assessed in terms of material and environmental impact in the dialogue both with the structure and the intervention context through a swot analysis.

CODE 373**URBAN REGENERATION OF VILLAGES AS AN OPPORTUNITY.
TOOLS AND METHODS IN THE CASE STUDY OF MOGORO IN SARDINIA****Atzeni, Carlo^{1*}; Cadoni, Stefano²; Marras, Francesco³**

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Web: https://www.unica.it/unica/it/dip_ingcivile.page1: e-mail: carlo.atzeni@unica.it2: e-mail: stefano_cadoni@unica.it3: e-mail: francesco.marras@unica.it**KEYWORDS:** Conservation; Urban regeneration; Type; Habitat; Project.**ABSTRACT**

This paper shows the study conducted on altered fabrics near the historic center of the Sardinian rural village of Mogoro, with the aim of enhancing the architectural and urban identity and redeveloping the building fabrics in terms of housing quality. The transformations and adaptations of settlement structures and living spaces are characterized by a vision linked to the processes.

The interpretation of the crisis of life in the city allows us to re-evaluate the structural housing conditions of rural villages (in terms of ecology of domestic space, low density, large open public and private spaces, social distancing, cohesion and social support, etc.) as an opportunity for a renewed relationship between man and landscape. The PPCMM incorporates the needs of the regional settlement and proposes an open and flexible system of rules that accepts the processes that are coherent with tradition. This principle of inclusiveness is the basis of a strategy that aims to improve living conditions in smaller towns, keeping their dynamism alive. This is a relevant aspect today, in light of the profound crisis that cities are going through, worsened by the effects of the pandemic.

On a methodological level, the object of conservation is not exclusively the form built as such, but is expression of the principles of settlement. The modification takes place within an operational strategy internal to the processes currently in progress, not with the aim of crystallizing them, but of directing and bringing them back to a system logic.

On the operational level, the general approach is systemic and inter-scalar and acts through an acupuncture implementation declination. The type-morphological analysis of the fabrics, the identification of areas and buildings to be conserved, and the definition of a system of “rules” and types of admissible intervention results in a system of analytical abacuses as project tools, referred to transformations and mitigations. The definition of the strategic framework for tissue regeneration is completed with a coordinated sequence of pilot projects with the aim of sustainable reactivation of urban voids, together with the enhancement of the historical network of wells as an identity character of the public space.

CODE 13

**RECOGNITION AND IMPROVEMENT OF LOCAL TECHNIQUES,
CONTRIBUTION TO THE RE-ROOTING AND EMPOWERMENT OF
COLOMBIAN COMMUNITIES IN POST-CONFLICT**

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KEYWORDS: Post-conflict; Built heritage; Vernacular architecture; Peacebuilding; Peace heritage.

ABSTRACT

The role of memory as an instrument in the reconstruction of the communities affected by the armed conflict in Colombia is fundamental, it contributes to the restitution of their sense of belonging, autonomy and sustainability; contributing to the fabric of a country that seeks to be increasingly supportive and egalitarian. Among many possible strategies, this research program assumed the importance of the tangible and intangible heritage of vernacular constructions, as a mechanism to once again foster roots in post-agreement Colombia. In a broad concept of technology, the materiality of local buildings is studied in relation to their communities and the possible basic elements of economic, social and environmental sustainability are identified, as well as social mobility, as an alternative to impoverishment, migration or displacement generated by uprooting in these communities. The research focuses on the characterization and documentation of the traditional construction systems of local architecture, as well as the knowledge and skills that have been lost in these complex socioeconomic and political processes, even when the communities must inhabit another territory that is not their own. The affected communities are involved, seeking to make them recognize the value of their own knowledge in new homes or their improvement, to reconnect with the territory and with its memory. A participatory work methodology applied with Colombian communities was formulated since the 2016 peace agreement was signed, work is being done to make visible their own knowledge and the potential of the territory they occupied or abandoned due to the conflict. In these experiences, students have played a relevant role by recognizing the problems that their generation must solve; their participation has fostered in the communities the reunion with their memory and with their territories, demonstrating that the valuation and protection of heritage is an effective tool in the processes of reparation and care of the victims.

CODE 169**THE SOCIAL PARTICIPATION IN THE CASE OF
MANGUINHOS HISTORIC ARCHITECTURAL NUCLEUS (NAHM)****Almeida, Roberta dos Santos^{1*}; Pinheiro, Marcos José de Araújo²**

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e-mail: marcos.pinheiro@fiocruz.br, web: www.coc.fiocruz.br**KEYWORDS:** Cultural heritage; Conservation; Sustainable requalification; Social participation; Manguinhos Historic Architectural Nucleus (NAHM).**ABSTRACT**

The debate around social participation integrates different studies about cities and public spaces. By focusing on heritage sites preservation and management, one can understand its integration with human social life as a vital factor to promote heritage conservation, sustainability and to guarantee human and cultural rights. The present study reinforces this approach to analyze the case and the requalification plan of Manguinhos Historic Architectural Nucleus (NAHM), a cultural heritage site located on Fundação Oswaldo Cruz (Fiocruz), Rio de Janeiro/Brazil. This plan is in the course since 2014 and it aims to adapt and create new uses of NAHM urban areas and historical buildings to conform a park with social and cultural activities freely offered to the population by the Museum of Life, an institutional museum dedicated to science popularization and dissemination.

It is based on the results obtained from a social survey part of a Master's degree project, which included both methods of interviews and online questionnaires applied for different interest groups. The project aims to analyze the social participation dimension adopted by this requalification plan and, on the other hand, perceived by these groups both in terms of appropriation and valuation as well as the collective construction of their proposals. We observed that the NAHM requalification plan puts into practice some important initiatives, reiterating its importance for cultural heritage sustainable management. However, our research also found that it is highly necessary to amplify the communication between territory agents and to expand social participation tools, both of which have been inconsistent so far.

CODE 327

**CITIZEN PARTICIPATION FOR HERITAGE INTERVENTION.
AN EXPERIENCE IN LUCENA (CORDOBA)**

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KEYWORDS: Architectural Rehabilitation; Enhancement; Heritage and Citizenship; Participatory Processes; Social Recognition.

ABSTRACT

This paper presents a participatory experience implemented in the medium-sized city of Lucena (Cordoba) to develop a proposal for intervention on fifteen public heritage buildings. The work was based on identifying the network of key actors, including technical and political managers of municipal areas, the Municipal Corporation and society, through representatives of citizens' groups and associations. It should be noted that mobility and meeting restrictions due to the pandemic caused by the SARS-CoV-2 coronavirus should be added to the usual difficulties in these processes. Consequently, a dual participatory process has been defined, consisting of interviews with representatives of the different political parties of the Municipal Corporation and a digital survey disseminated among social agents and public servants.

The survey has been designed with a common structure of questions for both groups. In addition to statistical information, questions have focused on the cases studies and the collective needs. The internal view, represented by the municipal employees, has been completed with specific questions on the conditions of the workplaces and the functional and logistical needs derived from their job.

Individual, collective value and cultural relevance deserve separate mention. The definition of a particular programme of uses and, mainly if it implies changing the existing ones, must necessarily consider the value. At the same time, its relevance on a cultural level makes it possible to detect a general recognition as part of the heritage and identity legacy of the municipality. The importance attached to a building can be a determining factor in accepting substantial changes to it.

The survey made it possible to identify response patterns, based on which the research has defined a list of potential uses and the necessary interventions for rehabilitating each of these buildings. In short, the communication aims to demonstrate the usefulness of this type of participatory methodologies also in cultural heritage rehabilitation processes.

CODE 5**COLLAPSES IN GLUED LAMINATED TIMBER STRUCTURES OF COVERED POOLS, DUE TO MISTAKES IN ASSIGNMENT OF USE CLASES**

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KEYWORDS: Collapse; Glued laminated timber; Indoor pools; Use classes.

ABSTRACT

For a long time, structures that support the facades and roofs of sports facilities such as indoor swimming pools, have been made of glued laminated timber.

The reasons that justify the choice of this material are various and regardless of the environmental, mechanical and aesthetic advantages, there is no doubt that the good behaviour and durability of timber in aggressive environments associated with the presence of salts, chlorine, etc., is possibly the factor that most influences its prescription for these type of projects.

However, in recent years there have been several collapses in pools built with glued laminated timber, due to the decay of their structural components by rot fungi, despite the fact that there were no sealing problems in their cover.

In most cases, the claims were not related to water leaks, but rather to the condensation of water vapour on the steel joints and other construction elements with poor thermal insulation.

The paper shows several examples of structural failures of this type, with some of the results of on site tests carried out to analyse the causes that led to these incidents. In addition, conclusions are shown in order for the designers to take into consideration some construction details that may improve the durability of these structures.

CODE 8

PERFORMANCE OF POZZOLANIC ADDITIONS TO CONTROL ALKALI-SILICA REACTION (ASR) PROMOTED BY AGGREGATES WITH DIFFERENT REACTION RATES

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KEYWORDS: Alkali-aggregate reaction (AAR) mitigation; Natural pozzolan; Siliceous coal fly ash; Silica fume; Blast-furnace slag.

ABSTRACT

Carbon neutrality in the cement and concrete sectors will be reached partially by using an increased number of industrial wastes to manufacture blended cements and, therefore, decrease the clinker factor; meanwhile, the Spanish situation concerning CDR (Construction and Demolition Residues) as aggregates is increasing. Such blended cements could counteract the effects of the alkali-silica reaction (ASR), which is a harmful, process that occurs between some CDR and other reactive aggregates and the alkaline compounds present in the pore solution of mortars and concretes. This paper assesses the ability of four pozzolanic materials (natural pozzolan, P, siliceous coal fly ash, V, silica fume, D, and blast-furnace slag, S) to mitigate ASR-expansion. In addition, compressive strength, open porosity, ASR-expansion testing in mortar bars and SEM microscopy were performed. The most important contributions of this research work are summarized in two points: a) alkali-silica reaction mitigation efficiency depends on the reactivity level of the aggregate, i.e., the higher reactivity is, the larger efficiency was reported and b) silica fume and coal fly ash are the best pozzolanic additions to alkali-silica reaction expansion control.

CODE 9**PATHOLOGICAL MANIFESTATIONS IN SANDWICH VERTICAL PANELS:
CASE STUDY****Lordsleem Jr., Alberto Casado¹; Lira, Virgínia Queiroz²**

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e-mail: viriniaqlira@gmail.com, web: <https://www.pecpoli.com.br/site/>**KEYWORDS:** Innovative wall partition; Sandwich panel; Wall System; Pathological manifestations.**ABSTRACT**

Wall partition in prefabricated sandwich panels are associated with promoting design flexibility, reduced installation time, good mechanical performance and the use of environmentally sustainable materials. The construction technology, characterized as innovative, arouses the interest of Brazilian construction companies to present benefits in relation to traditional vertical non-loadbearing masonry. This study aimed to investigate the pathological manifestations that occur in sandwich vertical panel called the Wall System, consisting of an EPS (expanded polystyrene) core and plasterboard sheets, adhered on both sides by contoured fiberglass-reinforced plastic sheets by a frame of pultruded profiles. The methodology included the carrying out of case study research through the realization of a building that uses the Wall System panels. The identified manifestations were characterized in relation to their symptoms, causes, origins and classification. In addition, repair techniques were proposed in order to restore the quality of the panels. Risk priority was assessed using the FMEA (Failure Modes Effects Analysis) parameters; while, the risk degree was evaluated according to the parameters of the IBAPE (Brazilian Institute of Engineering Assessments and Expertise). The research result identified the occurrence of 60 pathological manifestations in the Wall System panels, classified according to the causes in five different types. Of the 60 manifestations found, 80% are associated with stains and disaggregation of the coating on external walls and in wet areas and wear of the coating on the inner faces of the walls. The main focus of origin of pathological manifestations is in the design and execution stages. None of the identified pathological manifestations compromised user safety. Risk priority as per FMEA in the Wall System sandwich panels ranged from low to moderate; while, the risk degree IBAPE varied according to minimum and medium. As a contribution, there is the identification of pathological manifestations in sandwich panel Wall System, whose knowledge can feed back the technology, providing an increase in the quality, through repairing it, and mainly, providing subsidies for the pathological manifestations do not reoccur.

CODE 23**ANALYSIS OF RECURRENCE OF PATHOLOGICAL LESIONS IN LOW-RISE
RESIDENTIAL BUILDINGS IN THE CITY OF MEDELLÍN**

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KEYWORDS: Recurrence of injuries; Residential buildings; Medellín.

ABSTRACT

Due to population growth, it is necessary to take advantage of spaces as a housing alternative, which leads to the development of the physical infrastructure of cities as a solution to the lack of housing that currently occurs worldwide; however, despite the number of residential buildings in cities, these with the passage of time begin to present deterioration processes generated by climatological factors, lack of maintenance, construction and design errors that put at risk the durability of the same. It is for this reason that, in this article, the recurrence of pathological lesions in residential buildings of low height (1-3 levels), in the city of Medellín (Antioquia-Colombia), with low and medium socioeconomic levels, corresponding to numbering 1, 2 and 3, is studied. With the methodological strategy established for the development of this mixed research, the systematization of results, ocular and photographic inspection of the lesions present in the different construction systems of the analyzed houses (18 in total) was achieved; which made possible the general classification of injuries, quantification and correlation between affected architectural elements with their respective causes of origin, thus allowing to establish recommendations for improvement, in relation to preventive and corrective actions in the future constructions of low-rise buildings located in the city of Medellín.

CODE 30**PARAMETERISATION OF THE DEGRADATION PROCESSES IN
COATED FAÇADES WITH ONE COAT MORTAR RENDERS****Carretero-Ayuso, Manuel J.¹; Pinheiro-Alves, M^a Teresa²; Sáez-Pérez, M^a Paz³**

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KEYWORDS: Vertical envelope; Coating; Damages; Degradation.

ABSTRACT

The interrelations behind specific degradation processes in a construction element are not often explored in scientific articles, since it is difficult to obtain data sets with large populations of anomalies. This is one of the main reasons for which degradation processes are not widely studied (especially with regard to their frequency and characterisation), and it is sometimes necessary to resort to statistical surveys of small samples. Nevertheless, some authors have tried to address this difficulty by carrying out nominal analyses containing a conceptual correlation matrix of the failures of a construction system/product and their possible causes. While the creation of these conceptual systems of diagnosis is important, it is even more important to empirically obtain, through specific studies on anomalies, actual data for all cases of each of the relevant degradation processes.

The goal of a sustainable construction process should be a building in excellent condition, and efforts should be made to reduce the need for, and complexity of, maintenance works. The knowledge of the most frequent anomalies enables an easy way to minimise maintenance interventions throughout a material or product's service life.

With this background in mind, one of the most common façade coatings was studied: one coat mortar renders. They often experience a number of issues, and these have been researched in a wide-ranging study, the results of which are presented in this communication.

For the characterisation of these anomalies, 11 different types of damages were identified, along with 26 different causes that were the primary reason behind said damages. The most important and novel contribution made in this study is the complete and detailed breakdown of each of the 95 interrelations produced by this material's degradation processes, as identified in the 2005 cases that were studied.

As a complement to the above information, the percentage distribution of damages by type of building in which they occur (residential, non-residential, new construction or rehabilitation) is also presented.

CODE 53**THE USE OF MACROPOROUS MORTAR IN THE REHABILITATION OF
HANDMADE BRICK WALLS WITH RISING DAMP**

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KEYWORDS: Cultural Heritage; Rising damp; Coating; Handmade brick; Macroporous plaster.

ABSTRACT

The water from the land that rises by capillarity usually causes damages to the base of the brick walls of old buildings, which is especially harmful in walls that belong to Cultural Heritage. In order to prevent the rising damp and improve the external appearance of the coated walls, obtaining a homogeneous and aesthetically pleasing surface, the use of plasters with special macroporous dehumidifying mortars is more and more frequent, which facilitate desorption. To verify the effectiveness of some of these products, various tests have been carried out in the laboratory following the process established in the EN 15801 standard with test pieces made with handmade bricks and uncoated lime and sand mortar and covered with three types of render: mortar lime, cement mortar and a macroporous mortar, in order to check the differences in water absorption from the ground. For desorption, another type of experiment has been carried out based on checking the drying time of the test tubes by desorption, once they have been saturated from a humid base under the same environmental conditions. It has been found that the different coatings have different behaviours.

CODE 59**INFRARED THERMOGRAPHY AS A TOOL FOR INSPECTION OF BUILDING DEFECTS IN COATINGS - A SYSTEMATIC REVIEW**

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KEYWORDS: Non-destructive testing; Infrared thermography; Coatings; Façades; Building defects.

ABSTRACT

The objective of this paper was to investigate research that used infrared thermography to assess the incidence of building defects in wall coverings inside and outside buildings, checking its positive and negative aspects, and the possibility of alternative use in other tests. The methodology followed the guidelines of the PRISMA Method for Systematic Literature Review - Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The results show a gradual increase in publications in the area over the years. The most frequently found building defects in the research were related to cracks and detachment in ceramic and mortar coverings, however, the presence of humidity, formation of biological colonies, degraded paintings, among others, were seen. The technique proved to be efficient for the detection of building defects in coatings, however, the identification of some of these damages is only possible when they are associated with another pathological anomaly or in the application of thermography combined with other techniques.

CODE 62**CONSTRUCTIVE STUDY OF THE SHIPWRECKED HOUSE IN
THE PORT OF BILBAO****Marcos, Ignacio^{1*}; Díez, Jesús²; Piñero, Ignacio³; Egiluz, Ziortza⁴**

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e-mail: jesus.diez@tecnalia.come-mail: ignacio.pinero@tecnalia.com**KEYWORDS:** Reinforced concrete; Chlorides; Marine environment; Sandstone masonry; Shipwrecked.**ABSTRACT**

The outer Port of Bilbao developed at the beginning of the 20th century in the Abra, the lower part of the Bilbao estuary opening to the sea. Until then, the Port had been placed in the interior of the estuary, with an access extremely difficult from the Abra, resulting in frequent shipwrecks. At the end of the 19th century, was needed a life-saving station to rescue vessels crews and passengers in the event of shipwrecks became apparent. Although the conditions of access to the estuary improved at the end of the 19th century due to it's channelling and the elimination of a sand bar that limited the depth at Portugalete, shipwrecks continued. Due this reason, in 1920 the Shipowners Association promoted a building for the "Salvamento de Náufragos y Cofradía de Pescadores" (Shipwreck Rescue and Fishermen's Guild), known today as the "Casa de Náufragos" (Shipwrecked House). The building has undergone several modifications since its creation, although its external image has been preserved. It is located in Punta Begoña, Getxo, and is protected within the coastal area of Getxo as listed heritage. It is a building partially built over the sea. Part of its foundations is directly on the seabed, which is exposed at low tide. Today it belongs to the Port of Bilbao, and before intervening again to restore it, a detailed construction study was carried out to assess its current structural composition, the modifications carried out to date and condition, paying special attention to its durability. This paper presents the results obtained, focusing on the original concrete and the exterior sandstone masonry.

CODE 84

**MONTEVIDEO MUNICIPAL OSSUARY.
INTEGRAL STUDY AND MANAGEMENT PLAN**

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KEYWORDS: Heritage; Brutalism; Exposed concrete; Pathologies; Tests.

ABSTRACT

In 1959 Bayardo and Tizze completed the plans for a building that houses funeral urns. The structure, made of exposed reinforced concrete, was completed in 1962 and contains a huge mural by Edwin Studer. In this work, discussions of the time emerge: the sculptural assessment of the load-bearing system, respect for materials, the integration of the arts, the obsession with geometry and the notion of architecture as a collective work. Its values were recognized in different international publications, occupying a prominent space in the exhibition Latin America in Construction: Architecture 1955-1980, held at MoMA in 2015.

Although it was designated as a National Historic Monument in 2014, it lacks a general framework that considers its maintenance and conservation. This document presents the results of the research carried out within the framework of an Agreement between the Faculty of Architecture, Design and Urbanism of the University of the Republic and the Municipality of Montevideo. In order to know the different construction systems and components that make up the building and determine the pathological processes that affect it, an ocular inspection, a damage record and analysis were carried out, as well as tests (electrical resistivity, depth of loss of alkalinity, contamination with CL⁻ ion, scanning electron microscopy, X-ray diffraction, permeability to air and water, surface hardness and resistance to compression and penetration) following the criterion of minimal damage to the building.

In addition, a study of the structural behavior was carried out through digital modeling and in situ survey of the deformations of some functional units. Finally, a diagnosis was made on the performance of the building. Based on this analysis, preventive and restorative interventions are currently being studied to guarantee the preservation of the building and its legacy to future generations.

CODE 107**ASSESSING AESTHETIC AND STRUCTURAL DETERIORATION IN HISTORIC BUILDINGS - A CONTRIBUTION**

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KEYWORDS: Cultural Heritage deterioration; Natural stone; Estremoz marble; Biodeterioration.

ABSTRACT

An important part of our cultural heritage assets is built of natural stone since it has always been a material of excellence due to its inherent characteristics. Despite the physical and mechanical properties that give relatively long durability as a construction material, some characteristics are less durable, namely color or eventual surface finishes. The alteration of its aesthetic features may be followed by the alteration of the physical and mechanical properties of the stone. In this way, it is crucial to characterize the material and perform regular diagnoses in the buildings classified as local cultural heritage to provide the necessary tools for future intervention campaigns of conservation and restoration.

Considering its chemical composition, each stone has a specific behavior when placed in a particular environment. Factors like humidity or temperature are strongly influenced by the weather, which will also influence the nature of microbial colonization. Keeping this in mind, the work here presented aims to demonstrate a non-invasive and non-destructive analytical methodology applied in the identification of deterioration phenomena in natural stone buildings, either by geochemical or biogenic pathways, using X-rays based techniques and through the identification of colonizing populations. This methodology was successfully performed in the marble on the main cloister of the Convent of “São João da Penitência”. The Convent is located in Estremoz (Portugal), is dated from the 16th century, and presents applications of local marble. Several pathologies were identified, ranging from aesthetic damage, where the color is strongly compromised, to detachment of relatively large fragments. Impurities in the calcite matrix and the action of microbial and pollution agents were considered as the main factors that are contributing for the deterioration of the natural stone applied in this historic building.

CODE 128

**ANALYSIS OF DOCUMENTAL AND EXECUTIVE PROCESSES OF
CONSERVATION OF BUILDINGS TAKEN AS HISTORICAL HERITAGE**

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KEYWORDS: Historical heritage; Cultural preservation; Public management; Pathology of constructions; Technical evaluation.

ABSTRACT

This scientific research paper aimed to develop a complete study about the buildings listed as historical heritage in the city of Uberlândia, state of Minas Gerais, in Brazil. The trajectory of the discussion of heritage preservation in Brazil is presented, as well as the socioeconomic situation of the city in order to establish a parameter to assess the level of maturity in the treatment of the theme. The technical knowledge of pathologies needed to approach the topic is also introduced. In view of this, three listed buildings are studied, bringing to research both their historical context and relevance to the local community, as well as interventions carried out in them and technical analysis of the procedures. Then, a study was built on the documental and executive processes of the interventions, evaluating their effectiveness. Finally, with the objectives of the paper achieved, it was possible to reach conclusions on the influence of engineering and public management on cultural heritage and its effects on buildings and the population.

CODE 132**STUDY OF THE HERITAGE BUILDING COMPLEX OF THE NATIONAL MUSEUM OF COSTA RICA FROM A HISTORICAL, ARCHITECTURAL AND PATHOLOGICAL PERSPECTIVE****Porras-Alfaro, David^{1*}; García-Baltodano, Kenia¹; Méndez-Álvarez, Dawa²**

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e-mail: damendez@tec.ac.crweb: <https://www.tec.ac.cr/escuelas/escuela-ingenieria-forestal>**KEYWORDS:** Building pathology; Cultural heritage; Built heritage; Building damages; Non-invasive techniques.**ABSTRACT**

The National Museum of Costa Rica is one of the most emblematic heritage building complexes in the country. In addition to its historical relevance, this group of buildings has several construction systems and materials typical of the nineteenth and twentieth centuries, which gives it great architectural value and constitutes an opportunity for the study of various types of damages. This work is part of the research project of the Tecnológico de Costa Rica: "Implementation of non-invasive techniques for the pathological study of heritage buildings", and presents from a historical, architectural and pathological perspective the process carried out with scientific criteria that justifies the use of non-invasive techniques. As part of the study developed jointly by the schools of Architecture and Urbanism and Forestry Engineering of the Tecnológico de Costa Rica, together with professionals from the National Museum of Costa Rica participating in the project, different stages were established to define its state of conservation. First, a historical and architectural study of the building complex was conducted, based on a review of primary and secondary sources, as well as field work. In addition, a process of documentation of previous interventions to the buildings was implemented and the current chemical, mechanical and physical damages were identified by means of an on-site survey. The information obtained was systematized through 27 detailed record cards, corresponding to the subdivision of analysis units proposed for the project, and architectural plans were developed with the respective location of damages according to their classification. With all this historical, architectural and pathological information, a digital file was created that systematizes the data and will contribute to decision-making for better management of the preventive conservation of historical buildings and restoration processes of the building complex. It is also the basis for generating knowledge and experience in the implementation of non-invasive techniques, such as thermography, photogrammetry, ultrasound, 3D laser scanning, and microscopy, among others, that will help in the pathological study of Costa Rican heritage buildings.

CODE 162**FACADE DAMAGE MAPS: A LITERATURE REVIEW****Lopes, Melissa L. F.¹; Silva, Maykon V.²; Bauer, Elton³**

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KEYWORDS: Facade; Anomaly; Damage map; Graphic representation.

ABSTRACT

The damage map is used to graphically represent the anomalies identified during the inspection of a building, allowing for qualitative and quantitative analysis. This article aims to present a literature review about the elaboration of facade damage maps, with a critical discussion of the different approaches presented. It was found that there is no defined standard for mapping, and several proposals have been presented in existing studies. Recently, new tools have been explored to facilitate damage mapping, such as photogrammetry, infrared thermography, laser scanning and the use of unmanned aerial vehicles (UAVs). Regardless of the methodology used, the damage map must represent the facade anomalies precisely and clearly, without excess of information, allowing easy understanding. It was observed that the use of hatches to represent the damage and colors to represent its severity is very efficient. In addition, the separation of the facade by zones and the overlapping of a mesh is interesting for the quantification of anomalies. The use of innovative technologies can facilitate the mapping, however, more studies are still needed in this aspect.

CODE 174**RADON EXHALATION FROM THE STRUCTURE OF HISTORIC BUILDINGS. A PROBLEM DETECTED AT THE TOWER OF HERCULES, CORUÑA**

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KEYWORDS: Radon; Historic buildings; Inner fill exhalation; Materials; Heritage.

ABSTRACT

Radon gas is a known pathogen and is classified by the World Health Organization as a grade 1 carcinogen. This gas, present in the earth's crust due to the spontaneous radium decay (abundant in granitic soils), appears in buildings through the enclosing construction elements. Building materials, which may also contain radium in their raw materials, are also a source contributing to indoor concentrations, although to a lesser extent. International studies give data of a balance between 20% for materials and 80% for soil. However, cases have been detected in which the contribution of materials and structures is much higher. This is the case of historic buildings that have a large structural mass with filler materials with high radon contents, such as those built with double sheet granite ashlar and interior filling. The study of the physical phenomena of gas transport from the interior masses through the joints between ashlars reveals a high exhalation similar to that of soils. This paper presents the case study of the Tower of Hercules in A Coruña. A Roman building with a high content of granitic material in its walls. It is analysed by means of exhalation tests on its walls that provide data of two orders of magnitude higher for surfaces with joints. An accumulation model is developed that helps to understand the singularity of flows in this kind of buildings. This proposed methodology is intended to be applied to similar buildings located through the analysis of cadastral data and georeferencing.

CODE 183**CLASSIFICATION OF BUILDING FACADES BY MEANS OF THE LEVEL OF PROTECTION CRITERIA**

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KEYWORDS: Buildings; Classification criterion; Protected facade; Unprotected facade.

ABSTRACT

The building's envelope systems, with emphasis on the facades, have a significant contribution to the performance of the building as a whole. The facades of residential buildings in the city of Brasília, Brazil, fit into the construction environment located in large urban centers and, for the most part, have four floors or more. The degree of protection of these facades can be determined based on criteria of the French norm DTU 20.1. This standard considers height above ground level, maximum location distance and direction of annual predominance of winds and rain. The classification divides into two major groups of protected facades and unprotected facades. This classification is important mainly because the exposure factor of a given facade is directly associated with its degradation. Given the relevance of the degradation of materials, elements and ceramic coating systems, the objective of this study is to classify building facades by the criterion of the degree of protection. The analysis and classification are made for 65 samples of facades located in the mid-west region of Brazil. For this, the four main orientations North, South, East and West are considered in the hygrothermal simulation. The incidence of solar radiation and directed rain are variables that influence the degradation of the facades, regardless of the material used. These variables were considered and determined in the hygrothermal simulation. It is evident that facades of nearby buildings and even facades of different orientations in the same building presented different classifications regarding the degree of protection. In addition, the facades classified as protected present a lower tendency of evolution of the FGD in relation to the unprotected facades. The categorization of protected and unprotected facades is an essential tool for obtaining data that allow further studies on how the degradation process occurs, thus enabling the prediction of the useful life.

CODE 196**PATHOLOGIES IN THE ORNAMENTATION OF FAÇADES IN THE
ARCHITECTURE OF HISTORICIST ECLECTICISM
THE CASE OF MANIZALES (COLOMBIA)**

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KEYWORDS: Pathologies; Heritage architecture; Historicist eclecticism; Republican architecture.

ABSTRACT

The architecture of nineteenth-century historicist eclecticism acquired in Colombia the denomination of "Republican Architecture" due to the historical moment that the country was living at the beginning of the twentieth century. As in the rest of the world, in Colombia this style was used to design institutional buildings and even homes in many of the country's cities. In Manizales, an area enriched by the cultivation, processing and trade of coffee in the late 19th and early 20th centuries, republican architecture was the preferred style of the economically wealthier classes, the government and merchants to build their mansions, especially in the reconstruction of the city in the 1920s after two major fires destroyed nearly 300 buildings. For this reason, the city's historic center has hosted the largest repertoire of this architecture by architects from all over the world.

Of the initial buildings, 142 survive today, which should be preserved and protected as an important part of the city's architectural heritage. The facades and their ornamentation are exposed to damage and their maintenance becomes a burden for the owner. This work, in progress, that is, not yet finished, aims to identify, study and seek solutions to the most frequent pathologies in such a way that it becomes a contribution for the owners to make a proper maintenance. It also seeks to disseminate this knowledge in order to train construction professionals, workers and laborers to carry out appropriate interventions, as well as to generate social appropriation of this heritage among the community that coexists with the property through the implementation of appropriate strategies.

This work is done through observation and direct experimentation of the works studied. The method to generate social appropriation will be through direct work with the community, in a playful way, seeking the identification of the property, its knowledge, appreciation and care.

CODE 203**THERMAL ANALYSIS OF SODIUM SULFATE CRYSTALLIZATION WITHIN
POROUS BUILDING MATERIALS****Bednarska, Dalia¹; Koniorczyk, Marcin²**

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KEYWORDS: Salt crystallization; Sodium sulfate; Porous materials; Red clay brick; Differential scanning calorimetry.

ABSTRACT

Water with dissolved contaminations is a frequent problem faced in building materials. It regards both contemporary constructions, and those belonging to cultural heritage. Salt crystallization may cause significant degradation especially in case of porous materials, and sodium sulfate is probably the most dangerous one. The paper presents the results of thermal analysis experiments conducted on red clay brick saturated with 25% and 30% Na₂SO₄ aqueous solution. The investigation was performed using differential scanning calorimetry, and the precipitation was observed during cooling-heating steps from -20°C to +40°C. Calculation of the amounts of salt arising during each transition enabled one to identify the arising hydrates. It is observed that within pores of analysed material, sodium sulfate heptahydrate precipitates as the first one. Subsequently, the mirabilite precipitation is recorded. Additionally, the influence of cyclic salt precipitation on the brick's microstructure was investigated by means of mercury intrusion porosimetry.

CODE 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**

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KEYWORDS: GIS 3D; Crack panel; Point cloud; Mesh; Digital database.

ABSTRACT

The paper shows the approach used to analyze and document the conservation state of the Church of Santa Maria degli Angeli in Pizzofalcone in Naples. The Church was built between the 16th and 17th centuries and it was affected by events and alterations that changed its original structures. Although over the years it has been subjected to consolidation works, it currently has numerous cracks and it is affected by various deterioration pathologies that affect part of the wall and vaults, damaging the decorative elements too. The research activities focused on structuring of an operational process aimed to provide a mapping, in 3D GIS platforms, of the different phenomena found, in order to add attributes – not only descriptive ones – to the graphic visualization, which allow a typological cataloging and classification.

The methodological process for the construction of the database is based on the acquisition of information to know the current state of the artefact through the consolidated technologies of survey no-contact and multi-sensor. The reality-based point clouds and mesh obtained from these operations have become the 3D references on which to identify the phenomena and relate the drawing and information. The models have therefore been the subject of indispensable integration and editing processes (cleaning, simplification, segmentation and classification) in order to adequately prepare the data for import and management in the 3D GIS workspace.

The research is developed, therefore, in the field of experiments that intend to work on a conscious use of point cloud data and on the added metadata query according to logic that can be adapted to specific analyzes. Various theoretical and practical aspects were dealt, directing towards alternative uses of the various tools present in the software, so that application criticalities encountered were resolved from time to time. The results achieved so far are represented by the possibility of exploiting a 3D GIS database as a tool for deep knowledge of the mapped phenomenon for multilevel readings and diversified queries, in order to support decision-making processes and any maintenance interventions.

CODE 216**BUILDINGS INVESTIGATION OF DEGRADATION VARIABILITY IN
BRASÍLIA-BRAZIL CITY****Rodrigues Neto, Eduardo^{1*}; Bauer, Elton²**

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KEYWORDS: Degradation; Facades; Ceramic Coating; Variability; Coefficient of Variation.

ABSTRACT

The facades correspond to the external faces of all buildings and play a fundamental role in protecting the building against various degradation agents. The correct functioning and performance of the façades guarantee the maintenance of the building's useful life. The degradation that occurs in facades can have different behaviors depending on how it manifests itself, causing a certain degree of degradation in buildings. Thus, the present work aims to investigate the variability of degradation that occurs in the constructive elements of uprights on the facades of buildings. Thus, a database of buildings in the city of Brasília-Brazil was used, which contains the facades involved with ceramic coating and for the investigation only the data referring to the facade plummets were used, totaling 218 study samples, which form a set of 40 buildings. In order to meet the objectives, the data were analyzed using the Damage Factor and General Damage Factor degradation indicators and using basic statistical tools such as mean, standard deviation and coefficient of variation. In a general analysis, about 62% of the investigated cases had a degradation content of 0-20% of the total sample area and 57% of the cases had a FGD value close to the acceptable limit. Regarding variability, each building was studied in isolation and the FGD coefficient of variation of the samples showed a differentiation of degradation in the same building.

CODE 226**THE WOOD MOISTURE FACTOR ON THE BIOLOGICAL DETERIORATION
OF WOODEN STRUCTURES****Lima, Daniel F. ¹; Tenório, Marina²; Branco, Jorge M.³; Nunes, Lina⁴**

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KEYWORDS: Wooden structures; Moisture content; Monitoring; Biological deterioration.**ABSTRACT**

With sustainability as a growing concern, the rehabilitation of buildings arises as one of the main forms of support for the construction sector. Rehabilitation, in comparison with new construction, is seen as a path to minimize the negative impacts of this activity by reducing, for example, the energy consumption of buildings and its consequent impact on energy production (still meeting the current needs for comfort) and the extraction of raw materials. Wood has a high potential for numerous purposes, also, it is a natural, renewable, and sustainable resource, presenting itself as a promising construction material with enormous importance for the bio-based economy. However, despite being a traditional material, reliable service life prediction of wooden structures continues to be a challenge. Like other biobased materials, wood can be subject to biological deterioration by fungi and insects. The biological agents, when combined with favourable conditions (e.g., temperature, air relative humidity, wood moisture content, etc.), can lead to simply aesthetic damage, reduction in indoor air quality, or compromising its resistant load capacity, creating a risk to human health and safety, in addition to an increase of repair and maintenance costs. Many approaches consider wood moisture content as the key factor to control the activation of the decay process, since fungal colonization of wood requires a minimum moisture content of around 20%. Moreover, though subterranean termites (one of the most damaging wood insects) are able to infest dry wood, contact to moisture is fundamental for effective installation of the colonies. This paper addresses moisture as a conditioning factor in the degradation of wood in construction. The role of water on the development of the biodeterioration processes, the transport of water within wooden elements, as well as how the current normative references address the issue are discussed. Finally, this work presents some of the exiting methods for continuous moisture content monitoring systems that, associated with regular maintenance, can be an alternative to chemical treatments, increasingly limited due to current environmental legislation.

CODE 241**DEEP LEARNING FOR DETECTING CRACKS IN PAINTED BUILDING FAÇADES**

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KEYWORDS: Rehabilitation; Inspection; Cracks; Painted façades; Deep learning.

ABSTRACT

Building rehabilitation is a reality, and all phases of rehabilitation work need to be efficient and sustainable. Current procedures for assessing construction conditions are time-consuming, laborious and expensive and pose threats to the health and safety of engineers, especially when inspecting locations not easy to access. In an initial step, a survey of the condition of the building is carried out, which subsequently implies the elaboration of a report of existing pathologies, intervention solutions and associated costs. This survey involves an inspection of the site (through photographs and videos). This work aims to detect and locate cracks defects in images of painted facade walls of buildings. A VGG16 pre-trained model was evaluated first on a public database with cracked and not cracked concrete surfaces and then on a private database of images of painted building facades with and without cracks. The predicted activation maps were analysed with Grad-CAM methods to validate the models' prediction. The proposed model achieved 99% accuracy on the concrete public dataset and 78% on the building's facade private dataset. The limitations and the future works are identified.

CODE 265**IDENTIFICATION OF HERITAGE STONE BUILDING DEGRADATION
PATTERNS BASED ON DIGITAL PHOTOGRAMMETRY DATA**

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KEYWORDS: Bayesian probabilistic framework; Cultural heritage site; Digital photogrammetry; Material degradation pattern.

ABSTRACT

The deterioration of Cultural Heritage (CH) sites is one of the biggest challenges of modern societies for their important implications not only in our cultural identity, but also in safety and cost. In this sense, the assessment of higher-scale structural-level degradation is essential for decision-making. This paper applies a rational methodology for surface recession pattern recognition using digital photogrammetry and artificial intelligence tools. The identification is based on solid Bayesian probabilistic principles thus allowing uncertainty quantification in the assessment. As an example, a real case study for a 16th century CH building in Granada (Spain), the Real Hospital, is presented.

CODE 266**CASE OF STUDY: DIAGNOSIS OF 100 YEARS OLD ABANDONED MILL****Cetrangolo, Gonzalo^{1*}; Romay, Carola²; Mussio, Gianella²; Spalvier, Agustin¹**

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KEYWORDS: Masonry; Inspection; Pathology.

ABSTRACT

This work presents the results obtained from an inspection of a 100 years old mill. The structure was abandoned for several decades. The structure made of masonry was partially collapsed and the study was done in order to determine the extension of the damage and to take corrective measures to ensure its structural stability. The results were obtained mainly from a visual inspection, and they were complemented with laboratory tests on mortar and bricks. Different pathologies were detected in the building, and several types of cracks were identified. Differential settlements were detected at various areas of the building, and other areas suffered excessive loading according to the state of the bricks. Recommendations were made in order to maintain the building as a symbol of past local activity. Some walls should be removed, and others must be repaired to guarantee their structural stability, also the foundations must be inspected in the whole building and repairment measures should be implemented according to the findings. On the existing walls, it was recommended a reconstruction of the joints to bring proper bonding to the system. Finally, some recommendations of supplementary structural elements are presented with the construction of an auxiliary timber structure, that will enable the timber structure to structurally collaborate with one of the walls.

CODE 274**RECURRING DAMAGES IN THE EXECUTION OF
CONCRETE SLABS ON LARGE SURFACES**

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KEYWORDS: Pathology of concrete; Concrete slabs supported on the ground; Large surfaces.

ABSTRACT

The execution of large structural concrete surfaces is one of the most frequently used typologies. They can be found on the floors of industrial warehouses, large-area car parks, bike lanes, roads, airport runways, etc., either outside or inside buildings. In spite of this, they do not require such a detailed calculation of stresses as other structural elements and, normally, work is done with predetermined concepts, which gives rise to a very high number of problems that require intervention. These slabs, like deflected slabs, are also subjected to the actions of vertical loads, especially from traffic or other uses, but there is another group of different actions that are the ones that cause most of the damage. We refer to rheological and thermal actions. In this work, the different variables that contribute to stress states and their relationship with the main pathologies that occur will be analyzed. In the analysis, case studies will be referenced, and proposals will be made to avoid or reduce the probability of the appearance of the problems analyzed. The work will have a theoretical approach, contrasted with practical cases in which it has been intervened.

CODE 324**PATOLOGY AND NUMERICAL MODEL OF THE TEMPLE OF
SAN FRANCISCO TZINTZUNTZAN****Márquez, Alberto^{1*}; Olmos, Bertha²; Jara, José Manuel³; Martínez, Guillermo⁴**

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KEYWORDS: Conservation; Collapse mechanism; Truss; Church; Wood.

ABSTRACT

In the present work, a wooden structure in the Chapel of Solitude is studied and analyzed, which is cataloged as a cultural heritage of humanity due to the historical value of its construction and its typical ornamentation of the lacustrine zone of Lake Pátzcuaro, finding in the city of Tzintzuntzan. Due to the historical and cultural importance of the property, its conservation is essential, since it dates from the 17th, 18th and 19th centuries, its architecture is observed in neoclassical style with traditional indigenous influence, one of the most striking features is the display of a decorative wooden coffered ceiling in the form of a vault, which is decorated with various geometric figures. The main objectives of this work are to investigate possible collapse mechanisms that the reinforcements of the chapel could present due to loss of resistance of the wood, to estimate the loss of resistance that the wood affected by termites could have, and to develop a model for estimating the demands for deformations and mechanical elements to which the historical monument may be subject, based on the importance of its conservation and preservation of the historical heritage of the Tzintzuntzan community. The properties of the wood are determined by a tomography study of the damaged wood. Once the demands on the trusses and the resistance of the damaged trusses are known, the results will allow defining the components with the greatest risk, in order to take actions and propose recommendations that guarantee the conservations of the historical monument.

CODE 349**CONSOLIDATION OF A POROUS SANDSTONE USED IN ANCIENT CONSTRUCTIONS****Lamas, Pedro¹; Pinho, Fernando²**

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e-mail: ffp@fct.unl.pt, web: <https://www.cienciavita.pt/portal/BD11-B879-D8D1>**KEYWORDS:** Litoral fort; Aeolianite; Ethyl silicate; Consolidation; Analysis of the results.**ABSTRACT**

In the construction process of ancient structures, the local scarcity of good quality stone sometimes led to the application of less suitable materials regarding the environment aggressions. On the SW coast of Portugal there are some ancient military forts built with a local sandstone of aeolian origin (aeolianite) whose high porosity, combined with a matrix of weak cohesion, led to some degradation caused by the effects of seashore influence. One of these buildings is the fort of “Nossa Senhora da Queimada”, better known as “Pessegueiro Beach Fort”, classified as Property of Public Interest. While it was useful, between the end of the 17th century and around 1942, first as a military facility and after as a customs guard barracks, the fort experienced some preservation works. Since that last date, it no longer has any use; however, it underwent some rehabilitation interventions that, although highly beneficial in terms of ensuring its maintenance, were sometimes inappropriate, namely those that included the replacement of weathered structural elements by lithic material different from the original sandstone, both in visual terms and physical-mechanical features.

This paper describes the laboratory tests for the characterization of the aeolianite, based on specimens cut from samples taken from very degraded sectors of the fort's surrounding wall. Part of the stone specimens was subjected to a consolidating treatment by a commercial ethyl silicate being, subsequently, was subjected to physical and mechanical tests. For comparison purposes of each property, unconsolidated specimens, belonging to the remaining part of the stone specimens, were submitted to the same characterization tests. The work carried out confirmed the effectiveness of the consolidation treatment, in improving both the physical and the mechanical properties of the sandstone.

CODE 18

CHARACTERIZATION OF PIGMENTS USED AS PROTECTION AND DECORATION ON EXTERIOR FACADES OF HISTORIC BUILDINGS

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KEYWORDS: Pigments; Facades; Historical Building; Optical Microscopy; Mineralogical characterization.

ABSTRACT

All historical periods have their own specific characteristics and the color of the buildings is one of them, which can be present in the plaster or as a component of the substrate material. Originally, the plaster and coatings in buildings had a double mission: to protect and to decorate the walls, while nowadays, more importance has been given to the decorative aspect than to the protective function. From the end of the 19th century, with the appearance of the petrochemical industry, the use of natural pigments and binders was minimized and industrialized paints with artificial pigments were produced. The time and the different interventions suffered by many of the historic buildings, cause the loss of information of relevant importance in the conservation of historical heritage, significantly affecting the color, which has been eliminated or has disappeared hidden under layers of paints of later times. Thus, the objective of this research was characterization of painting layers superimposed on exterior facades and determination of their function in a late 16th century house located in the Colonial City of Santo Domingo, Dominican Republic. In order to revealed the history and composition of the original painting layers optical, mineralogical and microstructural characterization of the facades, techniques based on non-destructive (UV-vis spectrophotometry, Raman) or semi-destructive (X-ray diffraction, Scanning Electron Microscopy) methods have been used. Based on the comprehensive characterization of the 16th century painting layers, identification of one green and three red pigments was done. It was concluded that one of the red pigments had a role of waterproofing and biocide material, with the dual function, as a colorant and protective antimicrobial material.

CODE 26**VALIDATION OF ULTRASONIC PULSE TO QUALITY CONTROL OF
RECYCLED AGGREGATE SELF-COMPACTING CONCRETE**

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KEYWORDS: Recycled concrete aggregate; Self-compacting concrete; On-site quality control; Ultrasonic pulse velocity; Compressive strength.

ABSTRACT

One of the main operations in any civil work is to verify that the concrete supplied and placed on site reaches the required minimum compressive strength. This verification is usually performed statistically through the preparation and testing of a large number of specimens. However, its indirect control is also useful due to its simplicity, ease of execution, and low cost. One of the most common methods to perform this operation is the measurement of the Ultrasonic Pulse Velocity (UPV) of the cast concrete, checking that its value corresponds to the necessary concrete's strength class. This study aims to analyze whether this indirect measurement, widely used in vibrated concrete produced with natural aggregate, is also valid when large quantities of Recycled Concrete Aggregate (RCA) are added to Self-Compacting Concrete (SCC). For this purpose, six SCC mixes were produced with 100% coarse RCA and variable fine RCA contents (0%, 50%, and 100%). In addition, two different types of powder were used: limestone filler <0.063 mm and limestone fines 0/0.5 mm. The determination of the compressive strength and the UPV at 7 and 28 days in all mixes allowed demonstrating the existence of a close relationship between these two magnitudes in this type of concrete. It was even possible to develop highly accurate simple-regression models to interrelate both variables. These findings show that the use of SCC with RCA in engineering works would still allow the control of compressive strength using one of the most common traditional techniques, the ultrasonic pulse.

CODE 44**NUMERICAL APPROCHES FOR SOIL-STRUCTURE INTERACTION IN A
HISTORICAL INDUSTRIAL MASONRY BUILDING****Longarini, Nicola¹; Crespi, Pietro¹; Zucca, Marco¹; Scamardo, Manuela¹**

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e-mail: nicola.longarini@polimi.ite-mail: pietro.crespi@polimi.ite-mail: marco.zucca@polimi.ite-mail: manuela.scamardo@polimi.it**KEYWORDS:** Historical Building; Soil-Structure interaction; Masonry Buildings; Numerical Evaluations.**ABSTRACT**

Different numerical approaches were considered to investigate the possible causes of the structural damages detected in the masonry walls of an historical industrial building built at the beginning of the XX century in Italian Lombardia region; the building has a strategic role working as part of a drainage plant used for the reclamation of an extensive area close to the Po River. The structural analyses were performed with two different levels of complexity. In the first approach, structural finite element model and geotechnical one were implemented, independently. From the structural model, the forces transmitted to the soil are evaluated and applied to the geotechnical model. Consequently, the evaluated soil displacements are applied back to the structural model considering different boundary conditions: with fully restrained nodes, with base springs, and with imposed displacements. In such first approach the materials properties are linear. The second approach considered the implementation of a coupled model with both the building and the soil, modelled with solid elements having nonlinear properties. In the second approach, construction stage analysis was performed to evaluate the effects of the soil settlements occurred over time on the masonry structures and the foundation. A comparison between the results obtained by the two approaches is presented and the results are discussed to determine the causes leading to the cracks.

CODE 46**ENGINEERING SKILLS AIDED BY THERMOGRAPHY AND BIM**

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KEYWORDS: Operation Management; Thermography; BIM; Solar Geometry; Engineering Skills.

ABSTRACT

The quality of building operation management is related to the accuracy of the data collected in technical inspections. The control and monitoring required in the operational phase of the life cycle of an enterprise, challenges asset managers, especially in the identification of anomalies and in the rescue of information that help the planning of priority intervention actions. In line with the actions of world governance that have been demonstrating adherence to the Building Information Modeling (BIM) system, a building for public hospital use was used as an object of study in its renovation process. The study applies the constructive research method, which aimed to present a new work process applicable to engineering expertise. In this context, solar geometry aided by parameterized modeling was used. The building mass model was created using BIM in order to support the analyzes made possible by Thermography. It was concluded that the solar geometry simulated in the virtual scenario, add relevant value to the expert work process. In this direction, thermography is able to reveal the hidden elements present in construction systems, helping to identify structural anomalies and typologies. The construct represented by the As-is model makes it possible to retrieve data easily, supporting the decision-making processes, during the maintenance and operation phase of the enterprise.

CODE 60

**SEISMIC VULNERABILITY AND RETROFITTING OF A HISTORICAL
MASONRY BUILDING**

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KEYWORDS: Historical masonry building; Seismic vulnerability assessment; Modal analysis; Push-over analysis; Retrofitting.

ABSTRACT

The paper presents the assessment of the seismic vulnerability of a historical masonry building located in Milan. After the identification of the mechanical properties by means of in-situ tests and Italian Technical Code indications, a finite element plate model has been implemented to analyse the dynamic behaviour of the building through a modal analysis. The masonry has been considered as a homogeneous material. The intermediate floors, realized with steel beams, did not match the requirements to be considered as rigid diaphragms. Therefore, they have been modelled as plates with appropriate thickness and stiffness. Even if the analysis results showed a good behaviour in terms of vibrational modes and participating masses, the introduction of new floors has been considered to guarantee a proper distribution of loads and improve the box behaviour of the structure. A modal analysis of the retrofitted configuration has been performed and the results compared with the ones of the initial configuration. The retrofitted configuration has been also studied using the equivalent frame approach. A nonlinear static analysis has been performed to evaluate the capacity of the structure and estimate the seismic risk index.

CODE 64**THE FOURTH ARCH OF THE AUGUSTUS BRIDGE AT NARNI (ITALY):
A CASE STUDY OF ROMAN ARCH WITH RIBS****Custodi, Alberto^{1*}; Scaia, Flora²**

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KEYWORDS: 3D FEM modelling; Narni; Augustus Bridge; Second pier collapse; Northern arch.

ABSTRACT

The roman bridge said of Augustus (27 BC) is a monumental viaduct on the Nera River, north of the town of Narni.

The bridge is made up of four arches, of which only the first survives to the south, has always been a source of admiration for the size and the shape and has been the subject of technical studies and artistic representations.

The remains of the fourth arch, the northernmost, show a very particular ribbed appearance, noted by many authors, among all: Balance, Choisy and Galliazzo. Some authors indicate the fourth arch to be similar in some respects to other arched structures (bridges or basilicas roofs), for example to the roofing vault of the temple of Diana in Nimes or to the Roman bridge in Nimreh, ancient Namara, in Syria.

The authors of the present study, through a bibliographic research, having verified the diffusion of this shape in other Roman contexts, believe that at to date there do not seem to be other similar examples.

The fourth arch appears to be unique in relation to the arrangement of the voussoirs, which are set to be more connected than a simple overlap of elements. However, the different radial depth of the voussoirs could have caused less effectiveness, especially in relation to possible movements related to the thrust of the arch on the springer and in concurrence with the second (from the south) pier subsidence with possible detachment and the consequent collapse of the central voussoirs.

The subsidence of the second pier, which finally collapsed in 1885, is indicated by many authors as the main cause of the collapse of the central arch. In this work, the study of the subsidence and collapse of the second pier is also investigated through 3D FEM modeling of the pier and of the entire bridge. Finally, a set of 3D FEM models was presented to analyze the structural feature of the fourth arch of the Augustus Bridge, the executive assembly modalities, especially in the keystone area, compared to the same arch without emptiness among the ribs.

CODE 78**ANALYSIS OF VARIABILITY AND RELIABILITY OF STRESS WAVE MEASUREMENTS ON STRUCTURAL TIMBER ELEMENTS IN SITU****Osuna-Sequera, Carlos^{1,2*}; Luengo, Emilio^{2,3}; Cabrero, Juan Carlos¹; Hermoso, Eva¹**

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e-mail: e.luengo@aitim.esweb: <http://www.aitim.es>**KEYWORDS:** Existing timber structures; In situ assessment; Measurement variability; Non-destructive testing; Stress wave.**ABSTRACT**

In order to conserve the timber-built heritage, non-destructive techniques have traditionally been used for the identification of the pathological state, as well as for the estimation of the structural properties of timber elements. There are numerous works that present the correlations between mechanical variables with measurements obtained from commonly used devices. However, occasionally, in the in situ assessment of timber structures, several scenarios may arise where accessibility to the timber element may be limited or where the technician carrying out the measurements may question the number of measurements to be taken in order to obtain the minimum possible variability and maximum representativeness. The aim of this work is to analyse the reliability of the measurements made with one of the most widely used acoustic equipment currently in use by studying its variability, considering the position of the acoustic sensors at a distance of 1 m, in order to reproduce the possible in situ conditions mentioned above. The material used was 2 Scots pine (*Pinus sylvestris* L.) sawn timber beams with nominal cross-section 200x200 mm² and 4 m in length from a batch under study. As a result of the repetition of the same measurement, a mean coefficient of variation of 1 % was observed. The dynamic modulus of elasticity obtained varied between 369 - 1847 N mm⁻² for the piece with the best quality and between 532 - 3546 N mm⁻² for the piece with the worst quality, depending on the case studied (1 m length measurement, face or edge and volumetric cross-section). The variability in obtaining the mechanical properties in pieces of higher quality is more sensitive to the existence of wide ranges of variability in the wave transmission Time of Flight (ToF).

CODE 90**A NEW CLASSIFICATION METHODOLOGY BASED ON NON-DESTRUCTIVE TECHNIQUES FOR OLD STRUCTURAL TIMBER**

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KEYWORDS: Old wooden structures; Antique wood classification; Non-destructive techniques NDT; Non-destructive evaluation; NDE.

ABSTRACT

Non-destructive techniques (NDT) are broadly used to classify timber elements in sawmills, but these techniques do not take into account the numerous peculiarities and singularities of old wood. In order to determinate the mechanical strength of structural old wood in an accurate and reliable way through NDT, it is necessary to consider its particularities. Some of them are high density when comparing woodworms with wood used nowadays, high proportion of heartwood and a wide range of biotic degradations (i.e., by termites, woodworms, fungi).

Therefore, the present paper sets a new methodology to assess and evaluate old wood by using a combination of non-destructive testing techniques, which has been applied to a set of 98 timber elements coming from demolished buildings. The tree species corresponding to such elements are the most used in the past. The methodology includes different variables (density, average resistographic value, degradation level, degradation type, number of knots, species, sapwood/ heartwood ratio) to derive a structural classification scheme for old wooden elements, which also is compared with mechanical values of modulus of elasticity (MOE) and modulus of rupture (MOR) achieved by destructive bending test.

By using this methodology, the wide range of old wooden elements present in thousands of restoration projects may be classified in accordance with the Wood Strength Classes already used for the current timber as stated in its corresponding Wood Standards (CTE SE-M and Eurocode 5: Wood Structures). The methodology can be used for in situ evaluation and also for structural classification of elements recovered from demolition, which allows further reuse in buildings.

The comparison of the strength results obtained by the proposed NDT methodology and the values obtained by means of breaking tests shows good agreement. The statistical analysis gives R² values greater than 75% in the case of MOE, and 54% when considering MOR. Finally, a set of simple analytical equations including only 3 or 4 variables has been formulated aiming to provide an easy and quick handling classification tool for antique wood.

CODE 129**STRUCTURAL ASSESSMENT UNDER LATERAL ACCELERATIONS OF A
CONCRETE VAULTED MAYA BUILDING OF BONAMPAK, CHIAPAS, MEXICO**

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KEYWORDS: Maya concrete construction; Corbelled vaults; Seismic vulnerability; Nonlinear FE analysis; Concrete damaged plasticity.

ABSTRACT

Our research aims at evaluating the seismic vulnerability of concrete vaulted buildings of the Late Classic Maya complex of Bonampak, Chiapas, Mexico (circa AD. 580-800). Bonampak is famous for the Maya murals present in Structure 1, which are arguably the most complete and best-preserved murals of the ancient Americas. Structure 3 – the focus of the present initial study – is located on a platform at the edge of an earth-filled terrace. The platform is inclined towards northeast by an average 6° , likely due to a settlement of the terrace. We use 3D nonlinear FE models built in Abaqus CAE Explicit to evaluate the structural response under gravitational and lateral accelerations applied with a quasi-static approach. The concrete damaged plasticity formulation available in Abaqus is adopted to represent the masonry behavior. Material parameters are derived from published experimental tests conducted on Maya lime mortar and concrete from Yaxchilan, an archaeological site near Bonampak. The time-evolution of strain, kinetic, and dissipative energies is used to detect conditions of structural collapse. We systematically explore the sensitivity of the lateral capacity to the assumed material tensile strength, the inclination of the base platform, and the presence of the structure's bounding (lateral) walls in analyzed models. The lateral capacity of Structure 3 in its current state is found to vary depending on the assumed tensile strength of the material, with values between 0.14 g and 0.59 g for sectional plane strain models, and between 0.33 g and 1.0 g for full 3D models featuring bounding walls. FE analysis of our sectional models shows lateral capacities and failure mechanisms which converge towards the results from the vulnerability assessment of Structure 3 conducted by Flores and Orea in 2016 using a 2D rigid-body kinematic model based on limit analysis.

CODE 158**FUNICULAR ANALYSIS OF MASONRY VAULTS UNDER GENERAL LOADING CONDITIONS THROUGH A CONSTRAINED FORCE DENSITY METHOD****Bruggi, Matteo¹; Taliercio, Alberto²**

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KEYWORDS: Funicular analysis; Historical constructions; Masonry vaults and domes; Earthquake actions; Force density method; Load paths.

ABSTRACT

Funicular analysis is extensively adopted to assess masonry vaults and domes, especially those of historical interest. Surface structures (e.g., shells) are modelled as statically indeterminate networks experiencing only compressive stresses. The no-tension networks are supported along the boundary and are in equilibrium with vertical and horizontal loads applied at the nodes. Following the lower bound theorem of limit analysis, the structure is safe if a thrust network lying between the extrados and the intrados of the vault can be found.

In this paper, a minimization problem is formulated for networks of general shape with fixed plan geometry, subjected to arbitrary loads. The Maxwell number (i.e., the sum of the force-times-length products for all the edges in the network) is adopted as objective function, whereas both the so-called force densities and the coordinates of the constrained nodes are minimization unknowns. Suitable constraints enforce bounds on the vertical coordinates of the network nodes, along with the non-positivity of the axial forces in the network members. The ensuing problem is solved through mathematical programming techniques.

Applications addressing the equilibrium of curvilinear structures are shown, namely a cross vaults and a circular dome. The optimal thrust networks are compared with those found when adopting a suitable norm of the horizontal thrusts as objective function. Eventually, curvilinear structures subjected to both vertical and horizontal actions occurring in earthquake-prone areas are also dealt with.

CODE 159**EL HÓRREO, ARCHITECTURAL HERITAGE ELEMENT OF THE
PRINCIPALITY OF ASTURIAS. METHODOLOGY FOR THE INSPECTION AND
DIAGNOSYS FOR ITS CONSERVATION****Vega, Abel¹; Rodríguez, Soledad¹**

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e-mail: avega@cetemas.es, web: www.cetemas.es**KEYWORDS:** Wood; Heritage; Raised Barns; Structural Inspection.**ABSTRACT**

In 2020, under the initiative of the Dirección General de Cultura y Patrimonio del Principado de Asturias, the so-called Mesa del Horru was created, an interprofessional working group to study the current situation from a multiple point of view (both legislative and technical) of hórreos and paneras in the region. The incalculable value of these elements makes it necessary (in addition to reviewing the legislation relating to their cataloging, characterization, possible uses, etc.) the development of a clear, exhaustive and adequate methodology for its structural inspection that serves as support in the diagnosis and structural conservation, especially for older structures (there are structures dating from the 16th century) and those on which a change of use can be proposed and, therefore, new requirements in terms of loads and structural demands. This document sets out the criteria for the identification and quantification of damage derived from xylophagous organisms that may affect wood (major material in hórreos and paneras), the assessment of damage derived from structural failures and a categorization of all of them for the determination of conservation degree categories that serve as a tool for making decisions regarding the repair or maintenance actions that may be required. This work summarizes the technical document of inspection and diagnosis developed within the working group of the Mesa del Horru for the conservation of these very important heritage elements.

CODE 173**SHAKING TABLE TEST DESIGN OF A TYPICAL CHURCH
OF MORELOS STATE****Chávez, Marcos M.¹; Durán, Daniel¹**

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KEYWORDS: Historic masonry; Shaking table tests; Mexican churches.

ABSTRACT

This paper presents the design and preparation of a shaking table test of a simplified prototype of a typical Mexican temple of the state of Morelos, with the main objective to evaluate the seismic behavior of this type of structures that were seriously damaged during the September 19th Puebla-Morelos earthquake, in 2017. The model was built using a scale factor of 1:12 and irregular tezontle masonry with a lime-sand mortar. It has a rectangular nave, a dome, and a bell tower with a total height of 3.65 m. The seismic input at the base was defined as a synthetic ground motion to ensure that the model was subjected to high excitation. Additionally, a finite element model of the temple with a non-linear behavior was carried out to estimate its response during the shaking table tests.

CODE 179**DISPLACEMENT ANALYSIS OF WOODEN TRUSSES THROUGH DIGITAL SURVEY AND VISUAL PROGRAMMING TOOLS. THE BASILICA OF SAN PETRONIO IN BOLOGNA****Massafra, Angelo¹; Prati, Davide²; Predari, Giorgia³**

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e-mail: giorgia.predari@unibo.it, web: <https://www.unibo.it/sitoweb/giorgia.predari>**KEYWORDS:** Heritage at risk; Non-destructive techniques; Wooden trusses; Displacement analysis, Terrestrial Laser Scanning.**ABSTRACT**

Non-invasive diagnostic techniques for structural assessing heritage architectures are of utmost importance to guarantee their physical preservation. New structural investigation methods are being implemented using innovative digital tools since traditional numerical structural analyses usually require an in-depth knowledge of material properties that could be reached mainly through many destructive tests, which have high costs and could damage the architectural figurativeness of protected buildings. This issue is crucial when dealing with old timber trusses. Specialist literature often oversimplifies their behavior, basing its theories mainly on methods of investigation and calculation belonging to the 19th-century structural analysis. This approach neglects factors of primary relevance that undermine traditional models and make the behavior of wooden trusses quantitatively challenging to understand, such as transformations that occurred over the centuries and the considerable dispersion of the mechanical resistance values of materials. For these reasons, a new method of investigation has been developed, aimed at deepening the knowledge of wooden roofs. This method follows a different path from standard knowledge methods both from the technical and methodological points of view. This quick and non-invasive method has been set up as a support tool to analyze the hypothetical displacements of these covering systems, based exclusively on the exploitation of TLS (Terrestrial Laser Scanning) point cloud geometric information through visual programming generative algorithms. This approach purposely avoids taking into account material properties and joint typology. The focus of this paper is the most recent phase of a broader research project that has studied several wooden roof structures in the area of Bologna, Italy, belonging to a set of remarkable historical churches and theaters, all dating back to the 16th and 18th centuries. This latest step extends the survey to the roofing system of the Basilica of San Petronio in Bologna, which has a span of approximately 19 m. The workflow application allowed highlighting the deformations that the Basilica's trusses have undergone over time, improving the comprehension of their behavior, and highlighting the critical issues of the whole covering system. Such analyses suggested some hypotheses for future investigations on specific building macro-elements and could advise interventions for their preservation.

CODE 205

CONDITION ASSESSMENT OF SIDE CORRIDORS WITH THE USE OF AGGREGATIONS BASED ON FUZZY INFERENCE METHOD

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KEYWORDS: Building diagnostics; Fuzzy signature; Decision support system; Renovation; Strengthening.

ABSTRACT

Professional maintenance of the residential building stock and completion of the necessary renovation works on time will increase the life of the residential buildings and improve their condition. For this reason, it is important to create and apply condition assessment and decision support systems that uniformly and accurately determine the condition of individual building structures and buildings. Thus, the necessary interventions -taking into account the available financial resources- can be performed at the right time and in the right way. The ultimate goal of our research is to develop a decision support system that evaluates the damage of individual structural members and determines the condition of each load bearing structure, ultimately evaluating the entire building. It then suggests (if necessary) which of the available renovation methods to choose. In addition to the damage of the load bearing structures, the decision among the proposed methods of reinforcement is also influenced by architectural requirements and economic aspects. In the present phase of the research we have developed a method that determines the condition of side corridor structures based on the observed damage detected by visual building diagnostics (e.g. steel cantilever corrosion, stone plate cracks, stone plate abrasion). The side corridors are divided into three well-separable structural elements (cantilever, plate, balustrade) and their damage is analyzed separately. Qualification is made by a fuzzy signature based decision making system. In this, aggregations are based on classical fuzzy inference methods. The rule bases of the aggregation were constructed during this research. The final condition of the side corridor structure is affected by the combined condition of the three structural elements.

CODE 237**THE ROLE OF THE EARTHQUAKE VERTICAL COMPONENT ON THE
SEISMIC BEHAVIOUR OF MASONRY WALLS****Camata, Guido; Di Primio, Alice; Sepe, Vincenzo***

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KEYWORDS: Unreinforced masonry; Masonry walls; Micromodeling; Non-linear dynamic analysis; Earthquake vertical component.

ABSTRACT

In the professional practice and in building codes the seismic behaviour of ordinary masonry buildings is usually evaluated taking into account only horizontal components of the earthquake.

The recent scientific literature, however, has highlighted the role that vertical components of the seismic accelerations may play for unreinforced masonry (URM) structures, mostly in case of near-fault earthquakes, as also shown by damage scenarios observed after seismic events.

As a first step of a research in progress, this paper describes nonlinear analyses on a simple URM wall subject to seismic accelerations – both horizontal and vertical – recorded for a recent Italian earthquake. The analyses have been performed with a micromodeling approach recently proposed in the scientific literature, implemented in the OpenSees framework.

The results of dynamic analyses show that the base-shear vs displacements curves and the damage evolution – and therefore the capacity of masonry walls – may be significantly affected by the earthquake vertical component.

CODE 243

EXPERIMENTAL STUDY ON CALIBRATION FACTOR OF FLAT - JACKS

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KEYWORDS: Flat - jack; Calibration test; Masonry structures; Compressive stress.

ABSTRACT

An accurate diagnosis of the condition of historic buildings can only be made with knowledge of the structure and its component materials. Minor destructive tests are used for their assessment, offering minimally invasive procedures that are compatible with structures of high heritage value. Among these, the flat jack technique is one of the most widely applied in latest years for the structural assessment of masonry constructions. It is a direct and in situ method that provides, in its simple version, an estimation of the stress level; and in its double version, deformability characteristics of the structure, even allowing to estimate its compressive strength. However, the calibration coefficient (K_m) of the flat jacks plays an important role in the accuracy of the results obtained. In this regard, although some research has been carried out to date, the effect of the type of hydraulic fluid used to pressurise the flat jack has not been still analysed. Consequently, this paper presents the results of an experimental study to evaluate how the fluid's physical characteristics affect the calibration coefficient. For this purpose, various types of fluids with different viscosities and densities have been studied. The results of this research have shown that the influence of the hydraulic fluid in the calibration coefficient is moderately significant. For this reason, it is recommended that, before a test will be carried out, the flat jack - fluid system must be calibrated.

CODE 256**INSPECTION AND STRUCTURAL EVALUATION OF A MASONRY ARCH
FOOTBRIDGE, BAIRRO DOS ANJOS BRIDGE - LEIRIA****Christo, Guilherme¹; Veludo, João²; Gaspar, Florindo³**

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e-mail: florindo.gaspar@ipleiria.pt**KEYWORDS:** Stone masonry; Footbridge; Structural modelling; Laser scanning.**ABSTRACT**

Stone masonry was one of the ancient construction techniques. The simplicity of execution and the durability of the stone masonry structures had made it a popular building material. This is the reason why, of all the bridges built since ancient times, only stone bridges have survived. In the study of the structural behaviour of an old construction, it is important, before any other development, to obtain an overview of the temporal evolution, characterization of their structural aspects. The modelling of this type of structure is also very important since it allows to understand the structural behaviour, since for stone masonry there is always some uncertainty, which was used on a large scale in an almost an empirical way. A good understanding on how the masonry arch bridge loads influence the mechanical system is of utmost relevance. The bridge studied in the present work was made of limestone masonry, being composed of two arches, constructed on the 19th century. This study has been developed to support the preservation of the Bairro dos Anjos Bridge as historical heritage, under the responsibility of the Municipality of Leiria. The visual inspection and anomalies identified on the bridge are provided along the geometrical survey made. Taking in account the boundary conditions and static loads, and in order to study the structural behaviour of the bridge, a numerical analysis was performed using finite elements, with a 2D modelling using ROBOT software and 3D modelling using Ansys software. Based on the assessment done, the bridge is apparently in good structural condition, despite some non-structural pathologies identified. The use of a simplified model based on 2D finite elements seems to be suitable for an initial analysis.

CODE 258**INVESTIGATION OF MASONRY DEFORMABILITY THROUGH FLAT-JACK TESTING: A NUMERICAL STUDY****Alecci, Valerio^{1*}; De Stefano, Mario²; Marra, Antonino Maria³; Stipo, Gianfranco⁴**

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e-mail: gianfranco.stipo@unifi.it, web: <https://www.dida.unifi.it>**KEYWORDS:** Masonry; Finite element models; Elastic modulus; Double flat-jack test.**ABSTRACT**

The elastic modulus represents a fundamental mechanical parameter for evaluating the seismic response of structures. For existing masonry buildings, the in-situ estimation through double flat-jack tests is largely used but many problems arise for a reliable interpretation of the test outcomes. Formulas provided by Standards or available in the literature follow different approaches which results are strongly variable. Furthermore, these formulas do not take into consideration important practical aspects of test apparatus, like the position of the measurement reference points in the masonry sample. The arrangement of the gauge points can influence the displacement measurements and, consequently, the value of the elastic modulus. The present work aims at numerically investigating - through Finite Element (FE) models - the effects of the position of the gauge points on the outcomes of a double flat-jack test. In particular, a continuous FE model is adopted, in which the Concrete Damage Plasticity model implemented in Abaqus code is used to model the nonlinear behavior of the masonry. This study provides recommendations on the correct way to determine reliable values of the elastic modulus from double flat-jack testing. Furthermore, numerical results and their comparison with experimental data allow to do important considerations useful both in research field and in engineering practice.

CODE 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)**

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KEYWORDS: Operational Modal Analysis; Historic heritage; Royal Monastery of San Jerónimo.

ABSTRACT

The analysis and the evaluation of the structural integrity of the architectural heritage of modern cities is currently a key element for its correct conservation. It is well known that one of the main difficulties that can be detected in a numerical structural analysis based on finite element models of this kind of buildings is the high level of uncertainty associated with many factors affecting the behaviour of the structure. Changes in the mechanical properties of the structural materials, the soil-structure interaction or even the building construction process may be the cause of high changes between the results obtained from a numerical analysis and others estimated experimentally. In this sense, the use of non-destructive techniques such as ambient vibration tests and operational modal analysis (OMA) method are widespread as a process to identify dynamic properties of these historical constructions. Updating the finite element model from the dynamic structural parameters identified experimentally, allows the adjustment of these models in order to obtain a more accurate estimation of behaviour of the structure. In the present paper, the implementation of all these techniques on the church of the Royal Monastery of San Jerónimo (Granada, Spain), a Renaissance style church (1946) declared as an artistic historical monument in the General Catalog of Andalusian Historical Heritage, is described. Ambient vibration tests and the OMA method were used in order to obtain the frequencies and mode shapes of the chapel. The updating process involves the comparison of experimental parameters (natural frequencies and mode shapes) with the equivalent values of a FE model. Once finished this process, a FE model with a similar dynamic behaviour than the observed in the experimental model was obtained.

CODE 268**METODOLOGY TO MONITORING THE STATE OF CONSERVATION OF BUILDINGS' ROOFS USING MULTISPECTRAL IMAGES: CASE STUDY OF LEIRIA DOWNTOWN HISTORICAL CENTRE****Gonçalves, Luisa M.S.^{1*}; Gaspar, Florindo²; Veludo, João³**

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e-mail: joao.veludo@ipleiria.pt**KEYWORDS:** Building roofs pathologies; Heritage conservation; Multispectral images; Hybrid classification.**ABSTRACT**

In the present paper, the authors present an innovative methodology using multispectral aerial images with Very High Spatial Resolution (VHSR) and a hybrid image soft classification based on decision rules, for automatically extracting information of roof's materials and their degradation and pathologies in order to produce maps of roof covers' state of conservation. The methodology was applied to the roof covers of the historical downtown of Leiria in Portugal. To extract the required information, multispectral aerial images with a spatial resolution of 0.50 m were used. The methodology applied includes the following steps: (1) a soft pixel-based classification of the images to extract information about main roof materials and their degradation; (2) object-based classification at the building level, based on decision rules which include the results of the soft pixel-based classification and its uncertainty; (3) the automatic production of maps of roof cover materials and state of conservation; (4) evaluation of the correlation between the classification of the aerial images and the degradation of the timber roof structures. The classification accuracy was assessed from a set of samples selected by random stratification and from a second set of samples which took into consideration the degree of certainty of the classification obtained with each decision rule. The results obtained in the historical city of Leiria, show that multispectral images with this methodology can be an alternative to the traditional manual methods to extract ancillary information to monitor the state of conservation of building roofs where, usually, building degradation starts.

CODE 281**DIAGNOSIS OF MONUMENTAL STRUCTURES CONSIDERING HISTORY
RELATED-PHENOMENA: A SYSTEMATIC OPERATING METHOD APPLIED TO
THE BAPTISTERY OF PISA****Bartolini, Giada¹; De Falco, Anna²; Giuliani, Francesca²**

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KEYWORDS: Historical masonry structures; Non-destructive techniques; Structural H-BIM; Crack pattern.

ABSTRACT

The study of historical constructions poses several challenges due to complex geometries, poor knowledge of material properties, historical stratifications, and damage patterns deriving from past events. All these history-related phenomena are usually investigated through historical research, topographical surveys, as well as tests and inspections. These multiple and multidisciplinary aspects provide real data to build and calibrate structural models. Despite that, the potential for reaching an enhanced knowledge by their integration is not yet being exhaustively exploited. This paper presents a systematic operating method accounting for different sources of knowledge and building their synthetic and effective representation into an informative model. It is conceived as the first step of a broader framework aimed at better understanding masonry heritage structures considering history-related phenomena. The method is applied to study the Baptistery of San Giovanni in Pisa which presents an interesting crack pattern. A geometrical model capable of adequately representing the complexity of the monument has been obtained by means of a detailed 3D laser scanner point cloud. A monitoring system based on the measurement of the relative displacements of a set of key points on the monument has been set up to detect potential soil settlements, and additional data have been collected thanks to documents and historical representations. The informed three-dimensional model of the Baptistery shows the adequacy of this strategy to integrate the collected information and allows for collecting data-driven assumptions about the construction stages and the current state of the structure. These considerations can be used to build models to predict the structural behavior of the monument based on the availability of data.

CODE 282**GEOMETRIC APPROACH AND STRUCTURAL ANALYSIS OF THE TERCELETE VAULTS OF THE CAPTAIN MONTE BERNARDO CHAPEL OF THE SANTA DE SEVILLA CHURCH BY USING PHOTOGRAMMETRY TECHNIQUES AND THE FINITE ELEMENTS METHOD**

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KEYWORDS: Tercelete vaults; Masonry; Vaults geometry; FEM; Photogrammetry.

ABSTRACT

In the study of heritage buildings, usually there are not enough information about the construction and it is often added difficulty. The Monte Bernardo Captain Chapel (1.507) was built in addition to the Church of Santa Ana at a time when the construction of many monumental buildings in the city was being carried out. Among them, the Cathedral of Seville, where the first vault of these characteristics was built. Its construction represents a technological advance compared to the construction of the rest of the vaults of the Primitive Church thanks to the appearance of the Architecture Treaties during the 16th century.

Obtaining the geometry of this type of vault by traditional methods involves too complex and inaccurate work. Thanks to the use of new digital techniques, higher precision results are obtained that allow to deepen the study of the object and to elaborate three-dimensional models for its subsequent structural analysis. In the present paper, a geometric survey of the Chapel is carried out using photogrammetry techniques. In parallel, the theoretical layout set out in the Architecture Treaty of Hernán Ruiz “El Joven” is developed, adapted to the dimensions of the Chapel. In this way, both geometric models are presented, which allows us to evaluate the quality construction. Once the layout and dimensions of its ribs are known, a finite element model is developed to know the structural behavior of the vault.

CODE 302**SEISMIC VULNERABILITY ASSESSMENT AND RETROFIT MEASURES FOR
MEDIEVAL STONE MASONRY MINARETS IN EGYPT****Hamdy, Gehan**

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KEYWORDS: Conservation; Masonry tower; Seismic; Assessment; Retrofit.

ABSTRACT

Egypt contains thousands of minarets constructed throughout the past ten centuries that present a variety of architectural styles and have very high architectural and historic value. A destructive earthquake has struck Egypt in 1992 (Mw 5.9) and caused damage and collapse of many of the monumental minarets; especially stone minarets constructed between 1250 and 1520 A.D. This paper presents investigation of several iconic stone minarets in Cairo and assessment of their seismic vulnerability in order to determine the safety margins and suggest retrofit measures if necessary. In addition to field investigation, ambient vibration testing is to be made to identify the dynamic characteristics. Numerical modelling and dynamic analysis are carried out for the minarets. The results are analysed and related to the observed damages; results indicate that high stresses frequently occur at certain locations. It is concluded that irregular mass and stiffness distribution along the minarets heights made them more vulnerable to damage during earthquakes compared to other minaret styles. Also, harsh environmental exposure caused different levels of deterioration and damage that affect the seismic behaviour. The paper also describes retrofit measures made to a stone minaret constructed 1468 A.D. which showed obvious inclination following the strong earthquake in 1992. The actions performed for restoration and stabilization of the minaret are described. Dynamic analysis of the minaret after retrofit by micro piles showed improvement of the minaret seismic response: reduction of the lateral displacement by 20-36% as well as reduction of stresses in the minaret.

CODE 303

**MANAGING DIAGNOSTIC DATA FOR SEISMIC VULNERABILITY
ASSESSMENT OF BUILDING STOCKS BY AN INTEGRATE GIS/VR APPROACH**

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KEYWORDS: Building stocks; Seismic vulnerability; Diagnostic data management; GIS; VR tours.

ABSTRACT

Improving the seismic response of existing buildings requires the experimental assessment of technical characteristics and residual performances toward the reliable modelling of the structural behaviour and the selection of suitable retrofitting measures. For the purpose, the normative framework and the best practice acknowledge experimental measurements from onsite and laboratory testing as paramount for diagnosis and intervention. Particularly, in the case of building stocks, with territorial assets featured by common typological and constructional layout, technicians and managers might greatly benefit by the development of digital methods and tools for data collection and sharing for two complementary goals. On the one hand, the systematic cataloguing of the buildings and their diagnostic records, eventually fragmentary as coming from different professionals either/or acquisition periods. On the other hand, the correlation and validation of the testing results from a single site against the statistical distribution over a wider case system.

With reference to the above-mentioned issues, the paper is going to propose an integrated approach, based on geographic informative solutions (GIS) and photorealistic virtual tours (VR), for the structured assessment of a consistent set of buildings, by presenting the application on complementary and accessory works – guard houses, guard offices and central stations – of hydroelectric plants and dams in Central Italy. Based on the description of the proposed digital platform for remote direct access to the sites and consultation of relevant documents, reports and drawings at territorial scale, as a support for seismic vulnerability analyses, some insights on advantages and future perspectives of the proposed solutions for overall diagnosis, intervention and management of building stocks are highlighted.

CODE 321**FROM SURVEY TO ANALYSIS OF THE DAMAGE MECHANISMS IN STONE WALLS: DIAGNOSTIC INVESTIGATIONS ON A BASTION OF THE VENETIAN FORTRESS IN BERGAMO****Nannei, Virna Maria¹; Azzola, Pietro²; Mirabella Roberti, Giulio³**

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KEYWORDS: Laser-scanning; Decay occurrences; Damage mechanisms; City walls; Bastion.

ABSTRACT

The impressive city walls, built in the 16th century by the Republic of Venice around the city of Bergamo, are composed by many different functional and architectonic elements: 4 principal gates, 3 viaducts, 12 curtains, 11 bastions and 5 platforms, forming a complex defensive system that from 2017 belong to UNESCO World Heritage List.

The physical and environmental conditions of a system developing over a perimeter of 5 km and more than 70,000 m² of wall surface expose this huge work to continuous deterioration events. This is caused by the poor quality of facings and the lack of maintenance, particularly by the growth of infesting vegetation. In the case of the northwestern part of the fortress that originally hosted the defensive garrison, known as *Forte di San Marco*, decades of carelessness caused the diffused deterioration of wall facing. In this context, the northern corner of the *Valverde* bulwark shows huge cracking and ejection of some stone ashlars.

Together with the local University, the support of volunteers of *Orobicambiente* and the founding of *Fondazione Cariplo*, the Municipality of Bergamo carried on a deep diagnostic campaign focused on the *Valverde* bastion. By assessing the characteristics of the materials employed for building the wall and the causes of the crack pattern, the aim was to ensure both the monument conservation and the safety of the visitors. Starting with the geometric survey, the investigations ranged from the historical and archaeological analysis of the stone facing to the chemical-physical analysis of the materials and from the mechanical tests on specimens of stone and mortar to the interpretation of instability phenomena involving the northern corner of the bulwark. The integrated survey procedure and on-site examinations notably made it possible to understand the main causes of the damage and will be discussed here.

CODE 325**STRUCTURAL ANALYSIS BY IN-SITU EXPERIMENTAL CAMPAIGN AT THE
“TORRE DE LA VELA” OF THE ALHAMBRA DE GRANADA (SPAIN)****Suárez, Fco. Javier¹; Ortega, Javier²; Vuoto, Annalaura³; Lourenço, Paulo B.⁴**

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e-mail: pbl@civil.uminho.pt**KEYWORDS:** Rammed earth; Non-destructive testing; Numerical modeling; Alhambra; Seismic assessment; Laser scanning.**ABSTRACT**

The present work shows the non-destructive evaluation (NDE) works carried out in rammed earth structures (towers and walls) of the Alcazaba, at the Alhambra de Granada (Spain), aiming the characterization and evaluation its state of conservation, and to improving the knowledge about the structural and seismic behavior of the rammed earth structures.

The experimental campaign included the following works: - 3d laser scanning; - Dynamic identification tests using ambient vibration as the source of excitation for the characterization of the dynamic properties of the wall; - Characterization of the load bearing masonry walls through sonic tests to estimate the mechanical properties; - Ground-penetrating radar (GPR) to evaluate the internal constitution of the wall and qualitatively assess the state of conservation in the interior.

The results of the experimental campaign allow us to obtain sufficient knowledge of the structural elements and materials to generate a numerical model that accurately simulates its structural behavior. The safety evaluation is carried out using finite element modeling and performing nonlinear static analysis. In a first phase, a numerical model of the tower was prepared based solely on bibliographic review and a first set of analysis was carried out. After the in-situ non-destructive evaluation campaign, a second set of analyses was performed using an updated model calibrated with experimental results. The results are systematically compared, highlighting the importance of on-site works for a correct safety assessment of historic structures.

CODE 326**HOMOGENIZED NONLINEAR PROPERTIES OF URM STRUCTURES****Valadao, Ryan Manuel^{1*}; Pantazopoulou, S.J.²**

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e-mail: pantazo@yorku.ca**KEYWORDS:** Masonry; Homogenized masonry properties; Masonry composition; Composite material.**ABSTRACT**

Before the proliferation of concrete, masonry was the main form of construction, having evolved over thousands of years. Being a composite material comprising bricks and mortar, masonry is complex to analyze on account of the interactions between the constituents, which affect the material properties and performance. In seismic assessment of existing unreinforced masonry constructions, the most critical uncertainty relates to the description of homogenized equivalent material mechanical properties, which affect the estimated demands on structural masonry components and their corresponding resistances. Through detailed, nonlinear numerical parametric finite element studies, the objective of this research was to quantify the effect of brick and mortar interaction on mechanical performance and homogenized material properties of masonry. The study considered the brick layout, mortar joint thickness, material strengths and loading conditions as variables of investigation. The collection of cases studied were subjected to different load paths so as to study the response under vertical and/or lateral loads up to failure, with the objective to quantify effective strength and lateral stiffness and to illustrate the sensitivity of these important measures of resistance. The results demonstrated that altering the design factors significantly impacted the effective properties of the composite masonry material. It was found that results were most sensitive to brick layout and the mortar to brick compressive strength ratio, highlighting the variability in the effective homogenized masonry properties and the challenges to computational assessment caused by the complex nature of the material, thereby signifying the unpredictability in masonry as a composite material.

CODE 355**NON-DESTRUCTIVE TECHNIQUES USED IN THE DIAGNOSIS OF THE MANSARD ROOF STRUCTURE OF THE URIARTE DE HEBER PALACE****Torán, Susana¹**

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KEYWORDS: Heritage; Pathologies; Structural timber; Non-destructive techniques.

ABSTRACT

At the end of the 19th century, Montevideo had expanded from the old colonial center to the New City, which was characterized by a prosperous financial and commercial activity established on 18 de Julio Av., its main avenue where prominent public buildings, sumptuous homes or large buildings for rent were located. In this urban artery created to link the colonial city with the territories outside the walls, there are iconic works of Montevideo architecture belonging to different periods and styles, including the Uriarte de Heber Palace, located on a corner pattern, designed in 1897 by the french architect Alfred Massüe in an eclectic historicist style with symmetrical façades and two bodies of mansards.

In 1982 the State expropriated the palace and transferred it to the Banco de la República, the official bank of the country. In 1985, renovation and adaptation works were carried out on the interiors for the banking and museum activity. Comparing historical photographs, it can be deduced that between 1985 and 1996 the mansards suffered important alterations in the original and ornamental construction system. The southwest mansard was modified by the installation of an elevator and the incorporation of new service premises.

This work presents the diagnosis and the methodology used in the inspection. Damages caused by different agents were detected using simple visual recognition techniques and non-destructive, portable instruments for use on site. Thus, initial data on the state of each element of the structure were obtained and the areas to be verified were determined with a Sylvatest and thermographic camera. The inspected pieces were recorded in cards, identifying with a color according to the appearance they presented according to the F. Rinn methodology. Subsequently, three-dimensional graphs were made indicating the damage and severity of the injuries to each structural element, in order to quantify the parts to be repaired or replaced. Finally, although 70% of the wood is in good condition, despite little maintenance in more than a century, treatments were proposed to counteract the damage and preventive measures to avoid attacks by xylophagous insects and fungi.

CODE 359**EVALUATION OF HISTORICAL STONE STRUCTURES UNDER EXTREME ACTIONS USING RIGID SOLID DYNAMICS METHODS. CASE STUDY: THE ALCÁNTARA BRIDGE, SPAIN****Suárez, Diana¹; Goicolea, José María^{*1}; Tarque, Nicola^{1,2}**

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KEYWORDS: Alcántara Bridge; Rigid bodies; Finite element; Earthquake; Dynamic behavior; Historical constructions; Heritage structures.

ABSTRACT

The conservation of historical masonry structures must include resistance to dynamic actions, such as earthquakes, explosions, impacts, among others. These actions typically require the use of complex nonlinear models. In addition, these models present additional difficulties when dealing with masonry structures, limiting the applicability of the calculation models and finite element programs.

The research focuses on developing numerical models -formed by blocks- that fully consider rigid solid dynamics (3D), considering the normal and tangential nonlinear behaviour at the contact zones between all blocks themselves. The solution was performed in an explicit time-domain for dynamic analysis due to the extreme nonlinearity. One of the practical problems to solve here was related to the construction of the numerical model itself through the geometric placement of the different stone blocks, each with its shape and orientation. To solve this issue, scripts were written in Python that allowed systematising and facilitating the entire generation of models with thousands of blocks.

As a representative case study, the central pier of the Alcántara Bridge -located in Cáceres, Spain- was used. The bridge is an iconic work of Roman engineering (2nd century) with enormous heritage and historical value. After subjecting the central pier to a seismic action at the base, the results validated the expected collapse mechanism in this structure, characterised by the expulsion of the stone blocks and the progressive collapse of the internal infill. It is thus demonstrated that nonlinear modelling of masonry structures with rigid blocks can be an effective alternative to determine the seismic capacity of historic stone structures.

CODE 380**APPLICABILITY OF THE GROUND PENETRATING RADAR TO DETECT BUILDING SETTLEMENTS: THE SINGULAR CASE OF AN INDIANA HOUSE**

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KEYWORDS: GPR; Algorithms; Detection; Settlement phenomena; Architectural heritage.

ABSTRACT

This work presents a Ground Penetrating Radar (GPR) survey aiming to investigate settlement problems that compromise the structural stability of an Indiana style house (Cabanas, northwest of Spain). The construction, built in 1933-36, has an eclectic style with regionalist elements. The exterior façades are coated with cement and decorated with various mouldings that give it a particular character. Cement mortar was used to settle the building walls. Ten years later, the front area of the house, which extends 1-2 m away from the main façade, was levelled with anthropic filling and paved with cement, and an exterior retaining wall was built. There is a road with heavy traffic adjacent to the house. From a simple visual inspection, it is possible to observe external damage in the building façades (i.e. cracking), retaining walls (i.e. leaning, cracking and bulging) and pavements (i.e. potholes and subsidence). The GPR survey was conducted using a ProEx system with a 500 MHz antenna, which allowed to produce an overall image of the subsoil until a depth of 3-4 m. Although the GPR method has been successfully applied in geotechnical investigations, the interpretation of the data is a difficult task highly dependent on the experience of the interpreter and somewhat subjective. Different imaging techniques based on amplitude and textural attributes are presented in this paper in order to improve the interpretability of the GPR data. A GPR imaging approach was therefore adopted to highlight subsidence and poor soil compaction, which made easier the identification of building settlements. Comparing with the traditional method of punctual sampling, the GPR allows for a continuous diagnostic of the subsoil in a non-destructive way. The better knowledge of this settlement phenomena was promising for the engineers and architects engaged in the design of conservation activities for such a singular architectural heritage.

CODE 385**ANALYSIS OF THE SHEAR STRENGTH OF MASONRY WALLS ACCORDING TO THE DISTRIBUTION OF THE BRICK AND MORTAR****Reynau, Ricardo¹; Ivorra, Salvador^{1*}; Bru, David¹; Estevan, Luis¹**

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e-mail: r.reynau@ua.ese-mail: sivorra@ua.ese-mail: david.bru@ua.ese-mail: luis.estevan@ua.es**KEYWORDS:** Masonry; Brick bonding; Diagonal compression; Shear capacity.**ABSTRACT**

During the construction of houses and structures throughout the 19th and 20th centuries, the main technique used has the load-bearing brick masonry walls.

These structural elements have a reduced capacity against horizontal load like seismic forces, presenting a fragile behavior for these loads. In addition, the distribution of the brick units and mortar joints varies according to the type of bonding used by the master builders in different types of walls. With the aim of studying this behavior and evaluating the influence of the type of gear on the mechanical characteristics of the factory, different tests have been carried out in the laboratories of the Civil Engineering Department at the University of Alicante. Compression and bending tests have been developed for the characterization of the solid brick units. Likewise, the compressive and flexural strength of the hydraulic lime mortar units used in the joints have been determined. Finally, diagonal compression tests has been carried out, as to obtain the stress-strain curves of four masonry walls according to two well-differentiated types of brick bonding. The cracking pattern has been analyzed to obtain preliminary results about the in the shear capacity of these different walls, depending on the type of brick bonding used.

CODE 387**FROM PRELIMINARY STUDIES TO RESTAURATION OF CASA BATLLÓ
BY ANTONI GAUDÍ****Olona, Joan^{1*}; Bosch, Mireia²; Villanueva, Xavier³; Villanueva, Ignasi⁴**

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KEYWORDS: Restoration; Tests; Stucco.**ABSTRACT**

Historical images of the piano nobile as it was in 1927 show us partitions, doors, stuccoes and railings that in the period between 1955 and 1990 were altered and/or eliminated. This period can be best summed up by the fact that at the end of the 1950s, in the heart of Paseo de Gracia, the municipal brigade of the Barcelona City Council collected 104 wooden elements, between doors, shutters and closet doors attributed to Casa Batlló. Years later, the National Museum of Art of Catalonia-MNAC, carried out an inventory and to this day they are conserved there, with part of this collection on permanent exhibition. The modifications over time to the piano nobile, brought about both by the uses and the inhabitants between the 1950s and 1990s, created a substantial reduction in the value of the whole of the space as a composition.

Prior to the start of the intervention, studies and tests were carried out, to find out, check and determine the different methodologies and materials to be used. However, a careful inspection of the façade revealed pathological processes and undocumented findings about the construction techniques. These studies and the results of the tests allowed to agree upon the procedures and materials to be used. At all times, the guidelines set out in the project were followed, taking into account the ethical criteria and the methodologies established by national and international organizations linked to the conservation of historical heritage that had to be adapted to the specific problems of a recently intervened building. But these criteria had to adapt to two major problems: the lack of knowledge about the techniques used in the previous restorations and, on the other hand, some undocumented findings to date, of the construction techniques used by Gaudí.

CODE 390**VULNERABILITY ANALYSIS OF HISTORIC MASONRY TANK-TOWER USING
THE PHOTOGRAMMETRIC SURVEY: A CASE STUDY****Hyseni, Alba¹; Cascardi, Alessio²; Micelli, Francesco^{3*}; Aiello Maria Antonietta⁴**

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The structures built in forms of tower demonstrated to be flexible when involved in earthquake shaking and reacting against the seismic loads. On the other side, the collapse of masonry due to its fragility needs to be prevented. For this reason, an accurate mechanical and geometrical survey is a crucial aspect to be performed for a correct structural vulnerability analysis. Although the diagnosis of existing masonry buildings is now strongly supported by modern technologies (e.g. flat-jacks, ultrasonic pulse, hammer, penetrometer, etc.), the geometrical survey results still time- and cost-consuming, and therefore it is often made with dangerous approximation.

The present case-study concerns with a historical masonry tank-tower located in southern Italy. The structural geometry was assessed by digital photogrammetry supported by a drone able to remote-fly all around the tower while taking a set of photos. After the first phase of aero-photography, the point cloud was computed for a further digital elaboration, able to create the meshed surfaces. Furthermore, the geometrical model has been converted into a structural model, able to be processed through numerical analyses. In such a way, a static analysis, a modal analysis and a non-linear static analysis have been carried out by means of Finite Element Method (FEM). Two scenarios were considered, i.e. assuming the tank to be full or empty. The top-displacement versus the base-shear law was so-simulated. Lastly, the crack patterns were also compared in order to evaluate the influence of the tank on the damage of the tower.

CODE 399**PETROGRAPHIC STUDY OF THE MURAL PAINTING COATINGS OF THE SAN JORGE CHURCH (LEDANTES, CANTABRIA)****Sánchez Carro, Miguel A.¹; Quevedo González, Lydia²**

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KEYWORDS: Restoration; Mural paintings; Petrographic study; San Jorge Church; Cantabria.

ABSTRACT

The petrographic study using transmitted-polarized light microscopy is a common method in order to determine the mineralogical components of lime-based mortars. This paper first describes the restoration and preservation project carried out in the mural paintings of the San Jorge church (Ledantes, Cantabria) and, secondly, focuses on the petrographic study realized from two samples obtained from the painting's materials.

San Jorge church, located on the village of Ledantes (Vega de Liebana Council, Cantabria, northern Spain), is a masonry with ashlar in corners church that consists of only one body with the presbytery harbouring the mural paintings and placed on the head of the building. The church contains a Renaissance mural dated from 16th century (1568) that were made in secco, with no giornattas covering the surface, so it should be described like mural painting or fresco-secco. The project was carried out in 5 phases: a) main altarpiece disassembling, b) the sealing of the water paths that damaged the paintings, c) fixing of the pigments using pre-consolidation, d) reinstatement of the mortars and e) chromatic reinstatement.

Additionally, a petrographic study from two painting samples was carried out using transmitted-polarized microscopy. The study reveals that main components are: quartz, sandstone rock fragments, micritic patches, opaque minerals and voids. Monocrystalline quartzs are the most abundant components and according to their morphology a previous treatment by crushing is inferred. Rock fragments and micritic patches are the largest aggregates ranging from medium to coarse sand and exceptionally gravel. Opaque minerals have the same sorting in both samples, dominating the coarse and medium silt.

Four layers have been identified in the outer zone of the sample M2: black coating layer (L1), lime-based layer with carbonated and opaque aggregates (L2), brown coating with quartz aggregates (L3) and lime-based layer with finer aggregates (L4).

CODE 400**NDT MORPHOLOGICAL AND SPECTROSCOPIC ASSESMENT OF NANO
CONSOLIDATION OF THE LIMESTONE, THEBAN TOMB 109 OF WEST BANK,
LUXOR, EGYPT**

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KEYWORDS: CT Scan; Nanomaterials; Limestone; Consolidants; Luxor.

ABSTRACT

The Theban Tombs is one of the world's most significant archaeological sites. The Theban Tomb 109 or TT 109, is located on Luxor's West Bank. This study introduces a novel technique to compute X-ray tomography (CT scan) as a non-destructive technique to capture the morphology of the limestone's internal structure at the Tomb 109 or TT 109, as well as the stone's grain texture and the surface features through 3D images and videos. Additionally, this research examines the ability of a nanomixture that consists of tetraethoxysilane (TEOS) and Nanosilica to consolidate the limestone, which is also a novel approach that this study is introducing. It is worth noting that the limestone at the Tomb 109 has suffered harsh conditions such as groundwater and burial environment, which caused stone abrasion and weakness of mechanical properties. To confirm the behavior of the nanomixture and its impact on the stone's mechanical structure, this study uses cross-examination method using CT scan, SEM, and XRF analysis before and after consolidation. The final result shows that the nanomixture has increased the mechanical resistance of the limestone.

CODE 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**

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KEYWORDS: Earthquakes; Vulnerability; Social housing; Consistency.

ABSTRACT

The purpose of this work is to calculate the consistency ratio in the application of the Analytic Hierarchy Process multicriteria method AHP, used to determine vulnerability criteria in social housing in the city of Valdivia - Chile, in the face of seismic events, in order to obtain a result of the preferences and therefore a validated seismic risk matrix. Surveys of experts and users of social housing were used, the AHP method was applied in the R software, obtaining in the first instance the weights of each alternative, then the consistency ratio was calculated. Once it was verified whether the surveys are consistent or not, only the consistent ones were used to arrive at validated assessments by the method used, and then a new risk matrix. It turned out that the weightings differ, since their ordering changes, but they remain in the same three most relevant alternatives.

CODE 42**A CRITICAL ROUTE FOR DOCUMENTING THE SEISMIC VULNERABILITY
ON MEXICAN HISTORICAL CITIES****Ramírez Eudave, Rafael^{1*}; Ferreira, Tiago Miguel²; Romeu, Vicente³**

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e-mail: romvic@ua.pt**KEYWORDS:** Seismic vulnerability; Historical centres; Parameter-based assessment; GIS databases.**ABSTRACT**

The characterisation of the vulnerability of historical buildings towards seismic actions is a key action for their protection and care. Besides the existence of numerous experiences on the assessment of historical constructions, the implementation of urban-scale assessments is still an open discussion that involves the pertinency of the assessment methods, the strategies for data acquisition and the management of data in suitable data-bases. The earthquakes of 2017 in México permitted to contextualise the importance of pre and post-event data. This condition, relatively uncommon in the Mexican context, is useful for designing a coherent series of methods and existing applications, configuring a workflow for a large-scale seismic vulnerability assessment. By departing from the National Catalogue of Historical Monuments, it is possible to explore the use of simplified assessment methods based on material and geometrical parameters, such as the Vulnerability Index Method. The pertinency of using these methods is supported by the feeding of database from several sources, such as the Building Information Modelling and field-acquired information. The systematisation and consolidation of data by the means of Geographic Information Systems facilitate a circuit of acquisition, treatment and use of information. The present work presents the components and stages of a potential integrative system for the urban-scale assessment of seismic vulnerability. The earthquakes of 2017 in Mexico are an opportunity for discussing some limitations and opportunities of this workflow, investing a minimum of resources and using open-source software.

CODE 66**ON THE VULNERABILITY OF ANCIENT TOWN WALLS TO SLOW ONSET
EVENTS: FORMULATION OF A SYNTHETIC INDEX**

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KEYWORDS: Heritage Conservation; Vulnerability; Masonry Structures; Pathology; Town Walls.

ABSTRACT

Ancient masonry town walls are currently under threat due to several and diverse hazards. This contribution focuses on their vulnerability to slow onset events, including weathering conditions, environmental interactions, anthropogenic actions. The great extension of town walls allows for identifying the recurrent degradation and damage phenomena to create a portfolio of typical pathologies. The approach employs non-invasive technologies for the diagnostic of cultural heritage and introduces a tool to support decision makers in prioritizing restoration and retrofitting interventions, thus addressing preventive conservation. These tasks are extremely important for large-scale structures and for allocating economic resources that are often limited. Starting from the investigation of the current state of deterioration of a sample set of town walls in Tuscany, a specific survey form has been developed to support the evaluation of a vulnerability index. The application of the procedure provides a description of the typical degradation and damage phenomena affecting the town walls and a classification based on the synthetic vulnerability index.

CODE 79**A MULTILEVEL APPROACH FOR THE SEISMIC VULNERABILITY
ASSESSMENT OF MASONRY CHURCHES IN CUSCO (PERU)**

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KEYWORDS: Churches; UNESCO Sites; Seismic Vulnerability Assessment; Historical Centre; Cusco.

ABSTRACT

Seismic Vulnerability Assessment of buildings represents a fundamental tool for the prevention and mitigation of seismic risk, especially in those areas most exposed to earthquakes. The city of Cusco, whose historic center has been a UNESCO heritage site since 1983, has a long list of telluric events and the evaluation of the seismic response of the buildings is a crucial topic.

At this time, one of the building typologies arousing more concern, in particular in the historical center, is represented by churches. Given the architectural and cultural value of these buildings and the spiritual importance for Peruvian people, preserving this cultural heritage becomes urgent more and more.

Based on these premises, the seismic vulnerability assessment of the churches belonging to the historic center of Cusco is proposed in the present study. The adopted methodology is multilevel since it is based both on the analysis on the urban scale, using empirical methods based on observational methodologies and engineering judgments, and on the the analysis of a single church through numerical models.

This allows for the prediction of expected damage scenarios, identifying, on the one hand, which are the most vulnerable churches in the historic center, and, on the other hand, which are their main structural weaknesses.

CODE 82**EMERGENCY INTERVENTIONS AND COST ASSESSMENT FOR SEISMIC DAMAGES ON CULTURAL HERITAGE****Ferrari, Lia¹**1: Department of Engineering and Architecture
University of Parmae-mail: lia.ferrari@unipr.it, web: <http://www.madlab.unipr.it>**KEYWORDS:** Cultural heritage; Seismic damage; Risk management; First aid interventions; Cost assessment.**ABSTRACT**

Destructive seismic events, in Italy, significantly affected the local communities, causing significant extraordinary expenses. Among all direct and indirect costs of earthquakes, those of safety measures for damaged buildings represent one of the major expenditures in the emergency phase. Therefore, the cost assessment of seismic damages as well as the optimization of first aid actions are both crucial issues to effectively manage the limited economic resources and quickly restore the normal social-economic activities. However, emergency solutions employed in past events have often proved to be uneconomic, ineffective, and sometimes even harmful for the building itself, especially when dealing with cultural heritage. The research presented in the following investigated the Emilian emergency response after the 2012 earthquake to improve the management of economic resources and first aid interventions. In the specific, the interventions on damaged religious buildings were analysed in both their general features and individual singularities with the aim of identifying which are the factors that most influence the expense. As result, a method for cost assessment have been defined to identify an expenditure value according to the level of damage. Moreover, the first aid techniques have been studied in their operative, structural, conservative, and economic aspects to optimize the costs of safety measures. Strategies and practical indications of intervention were provided aiming at supporting the risk management for cultural heritage.

CODE 98

**HOW ARE HEAT WAVES PUTTING AT RISK HISTORIC URBAN AREAS?
FIRST STEPS FOR DEVELOPING RISK ASSESSMENT METHODOLOGIES**

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KEYWORDS: Historic Urban Areas; Climate Change; Risk Assessment; Vulnerability; Key Performance Indicators.

ABSTRACT

It is worldwide accepted that climate change is affecting cities and that the conservation of the cultural heritage contributes to sustainable development. However, despite the high level of interest and research in climate-change risks, a holistic understanding of the risk that heat waves and heat urban island phenomena present to urban cultural heritage is noticeably absent from literature. Aside from understanding the impacts that heritage faces with climate change, the consideration of loss of heritage and cultural values and assets due to extreme heat waves will promote the resilience and sustainability of both social and built environmental systems.

The aim of this paper is double, first to identify key performance indicators for risk assessment methodologies that address both the elements of historic urban areas as a system and the potential impact of prolonged heat waves. Second, this study aims at developing a categorization for both buildings and urban spaces within historic urban areas regarding their vulnerability to heat waves, which will be the basis for further risk assessment. For this twofold purpose, the interaction between urban spaces, heat waves, and the urban heat island is addressed as well as the vulnerability and behaviour of traditional materials and building typologies.

To define the elements that conform historic urban areas, the system is addressed from two perspectives, as an urban system, and as a historic area. At the same time, for a holistic approach, every element of the system is assessed, distinguishing between socio-economic, cultural, governance (services and resources) and physical (gathering tangible characteristics of all infrastructures, elements and buildings) aspects. The indicators and categorization are, therefore, essential for the evaluation of the impacts of heat waves and the urban heat island on the elements that conform the system of the historic urban area.

CODE 130**SEISMIC PERFORMANCE OF TYPICAL HYBRID BUILDINGS IN
THE URBAN CENTRE OF BARCELONA****Dimovska, Sara^{1*}; Saloustros, Savvas²; Pelà, Luca¹; Roca, Pere¹**

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KEYWORDS: Seismic vulnerability; Unreinforced Masonry; Hybrid steel-masonry structural system; Finite Element Analysis; Pushover analysis.

ABSTRACT

Unreinforced existing masonry buildings, located in many historical urban centres, present specific construction characteristics that can have a significant impact on their seismic performance. As these structures are often designed considering only gravity loads before the introduction of seismic codes, they are commonly found to be particularly vulnerable to seismic actions.

This work investigates the seismic performance of representative existing masonry buildings located in the Eixample district of Barcelona, Spain. These buildings are characterised by several common structural features, allowing grouping them into building typologies characterised by a similar structural response. The results of a building taxonomy of the specific district manifest the existence of two structural typologies related with the load-bearing system: one with load-bearing slender masonry walls throughout the whole height and a second hybrid one with steel beams and cast-iron columns on the ground floor and unreinforced masonry walls in the upper ones. The second typology is very common because it allows for large open space at the ground floor level, commonly used for commercial or administrative facilities. The drawback of this hybrid structural system is its reduced seismic performance, as the slender piers at the ground floor facilitate the development of a soft-storey mechanism.

The main objective of this paper is to evaluate the seismic vulnerability of a typical hybrid building system composed by steel frames on the ground floor and unreinforced masonry at the upper floors. The seismic assessment and the identification of the collapse mechanism of this building typology have been carried out using the Finite Element Method. Seismic loading has been simulated through non-linear static (pushover) analyses in two main directions (parallel and perpendicular to the façades). The results of the numerical analysis allow a better understanding of the seismic performance of hybrid steel-masonry building typologies. This work is part of an ongoing research devoted to a large-scale seismic vulnerability assessment of the most representative building typologies of the Eixample district.

CODE 134**THE “ALQUERÍA DE FALCÓ” (VALENCIA): SEISMIC VULNERABILITY
ASSESSMENT AND INTERVENTION STRATEGIES****Basset-Salom, Luisa^{1*}; Guardiola-Víllora, Arianna²**

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e-mail: aguadio@mes.upv.es, web: <http://www.upv.es>**KEYWORDS:** Seismic vulnerability; Vernacular architecture; Rammed earth; Alquería de Falcó, Valencia.**ABSTRACT**

In this paper, the seismic vulnerability of the “Alquería de Falcó”, a listed building declared Asset of Local Relevance, is presented. Located in the Torrefiel neighbourhood of the city of Valencia (Spain), it is a clear example of a typical manor house of the Valencian Orchard.

It is composed of two adjacent constructions built during the 15th, 16th and 17th centuries, with rammed earth and masonry bearing walls, one-way floors with timber joists and brick vaults infills, and tiled pitched roofs. The manor house has undergone several renovations over the years, being nowadays abandoned and presenting different structural pathologies and constructive damages.

Owned by the city council since 2017, after a first consolidation of the house in early 2020 and the evaluation of the current state of the main structural elements and of the foundation, an archaeological study has been started prior to the drafting of the rehabilitation project.

Despite being Valencia an area of low to moderate seismicity, most of the buildings built before the entry into force of the first Spanish seismic regulations present a high seismic vulnerability, as their design did not take into account many of the requirements to withstand horizontal loads.

In order to prevent significant and irreversible damages in the event of an earthquake, and as a complement to the studies prior to the retrofitting of the building, the seismic vulnerability has been assessed with the vulnerability index method, applicable to earthen and masonry structures. Moreover, the most determining factors and parameters that influence its seismic behaviour have been identified.

Finally, a series of intervention strategies are proposed to reduce the seismic vulnerability and to improve its seismic performance, preserving its architectural, cultural and heritage value. The results of this study can be implemented in the recovery and rehabilitation of other similar manor houses.

CODE 213

**RISK MANAGEMENT IN THE CONTEXT OF INTERVENTION WORKS
IN HISTORIC BUILDINGS**

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KEYWORDS: Risk management; Historic building; Collections; Intervention work.

ABSTRACT

The execution of intervention works can pose additional risks to historic buildings, their users and collections housed in them, besides those to which they are already exposed on a daily basis. There are several examples of buildings impacted by fire, vandalism and theft during renovation, restoration and maintenance work. This article aims to present the strategies adopted for risk mitigation during the execution of intervention works in the Pavilhão Mourisco, headquarters of the Oswaldo Cruz Foundation located in Rio de Janeiro, Brazil. The centenary building is listed by the National Historical and Artistic Heritage Institute and houses collections of great importance (Entomological Collection of the Oswaldo Cruz Institute, Rare Works Section of the Biomedical Sciences Library and exhibition areas of the Museum of Life). From the preparation of the "Risk treatment plan for the installation work of the new HVAC system" - which contemplated the risks for the environment, for the building, for mobile collections and for users - several measures were proposed for mitigation. This set of measures included various types of actions, including the definition of protocols, special programming of the Contingency Brigade to monitor activities, solutions to protect the construction elements, transfer of the library collection to a temporary storage area and training actions for the teams responsible for the execution of the work. Despite the great complexity of the intervention, considering the vulnerabilities of the building and mobile collections, the measures adopted ensured safe execution both for the professionals involved and for the cultural heritage.

CODE 245**CULTURAL HERITAGE BUILDINGS AND RELEVANT USES:
SEISMIC RISK ASSESSMENT IN FLORENCE****Cardinali, Vieri¹; Cristofaro, Maria Teresa¹; De Stefano, Mario¹; Tanganelli, Marco¹**

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KEYWORDS: Cultural heritage; Strategic uses; Seismic vulnerability; Urban scale; Florence.

ABSTRACT

The seismic vulnerability assessment of the buildings is an important issue of contemporary societies. Within this context, the preservation of Cultural heritage buildings (CHBs) is considered a cultural task for the transmission and transference of our past. Due to their beauty and significant architectures, several CHBs host nowadays public and important functions, such as municipalities, museums etc. In the city of Florence, several CHBs are spread all over the city. Most of these structures, although they represent heritage palaces safeguarded by the National superintendence, they are also listed as relevant buildings, therefore, due to their intended uses they have to guaranty support to society and citizens. It is worth noting that the preservation of historical buildings and the maintenance of certain safety levels appear to be in contrast. This paper presents a seismic vulnerability assessment of the strategic CHBs in Florence and their spatial distribution. The different structures have been investigated according to knowledge path recommended by codes. This phase involved the buildings individually. Then, at the urban scale, the structures have been divided into classes based on geometrical and structural features. The first level of evaluation of the “Guidelines for the evaluation and reduction of seismic risk of cultural heritage” has been developed. The results of the study provide a territorial assessment of the strategic buildings, at the basis for post-earthquake scenarios emergency planning.

CODE 278**PASSIVE ENERGY DEVICES FOR RETROFITTING FIRST
SOFT-STORY BUILDINGS IN MEXICO****García, Carlos¹; Jara, José²; Olmos, Bertha³; Martínez, Guillermo⁴**

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Hundreds of buildings in Mexico City were severely damaged during the September 19, 1985 earthquake (Mw=8.1) in Mexico City. Again the September 19, 2017 earthquake (Mw=7.1) caused building collapses and fatalities in the City. The earthquakes had different epicenter location and were produced in different seismic source. Whereas the first one was produced in an interplate seismic source in the Pacific Coast, the origin of the second one was an intraplate seismic fault. However, both ground motions produced buildings collapses of first soft-story buildings. Currently Mexico City and other cities in the country have an important number of existing soft-story buildings designed with old seismic codes. The observed damages during the occurrence of both earthquakes showed that existing first soft-story buildings must be analyzed to propose retrofit alternatives for mitigating the seismic risk in future earthquakes. Inspection of the damaged buildings conducted after the 2017 earthquake allowed to collect information on the main building typologies. This study analyzes the use of frictional, hysteric and viscous energy dissipation devices in soft-story buildings originally designed with a seismic code regulation of 1976. An energy-based multi-step methodology is used to design the energy dissipation devices of four residential three-, five- and eight-story buildings. The buildings were subjected to a family of real accelerograms recorded in the most damaged area of the 2017 earthquake. The results showed that the seismic vulnerability and the structural reliability of first soft-story buildings can be reduced with the use of passive energy devices.

CODE 289**TOWARDS AN EXPEDITIOUS METHOD TO ASSESS THE VULNERABILITY OF HISTORICAL MASONRY CHURCHES: PRELIMINARY ANALYSES BASED ON EMILIA (ITALY) 2012 EARTHQUAKES DAMAGE**

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KEYWORDS: Seismic vulnerability; Emilia 2012 earthquake damage; Expeditious assessment; historical masonry; Historic churches.

ABSTRACT

This study considers the peculiar historic heritage of masonry churches, with the aim of evaluating their seismic vulnerability, with particular reference to Emilia (Italy) stock, which was struck by a seismic sequence in 2012. The preliminary analysis that is carried out in this contribution is a necessary step towards the design of an expeditious vulnerability, damage and debris assessment method, in the frame of the financed BE S2ECURE Italian National Research Project (PRIN), which is undergoing.

A relevant sample of 11 masonry churches that were damaged by the earthquakes of 2012 is here considered, and their characteristics identified. In greater detail, damage state and mechanisms of the facade are assessed towards a novel expeditious vulnerability method later identification and validation. Indeed, in the historical built environment, historical churches are vulnerable to earthquakes and this implies risks not only for the cultural heritage conservation and its users' safety, but also for the safety of citizens and tourists in the immediate surroundings, due to the fall of debris from the facades. Towards the understanding of this specific risk, Out-Of-Plane (OOP) mechanisms are specifically considered in this contribution, due to their prominence in causing debris on the open spaces in close proximity to the church. Therefore, damage state is identified on the relevant sample, based on the indications contained in the "Italian Guidelines for the reduction of seismic risk of the cultural heritage" (A-DC PCM-DPC MiBAC, 2006), as well as by means of the more precise kinematic analyses on local mechanisms. These preliminary analyses and the present work are thus aimed at identifying the relevant parameters, such as e.g., wall thickness and slenderness, which could support the expeditious method later development for assessing vulnerability and debris from collapse or partial collapse of the façade, for the sample. The masonry churches composing the sample showed similar OOP damage state, and the kinematic analysis of local mechanisms supported the identification of relevant parameters, serving as the basis for the next phase of the research, i.e., tailoring the novel expeditious method for vulnerability and debris in historical masonry churches. The article is thus relevant for practitioners and researchers in the field of seismic vulnerability assessment of the existing and historic heritage.

CODE 315

**RISK COMMUNICATION AND AWARENESS OF THE BUILT ENVIRONMENT
THREATENED BY DISASTERS WITH DIGITAL MODELS**

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KEYWORDS: Risk management for Built Environment; Digital Models; Technical and Pervasive preparedness.

ABSTRACT

Natural and anthropic hazards are widely affecting the Built Environment causing damages and risks to the actual population and losses of architectural and environmental heritage to future generations. In particular, the potential value of historic city centres is threatened, both because of the intrinsic vulnerability of buildings and open spaces (squares, streets, and so on) and their high occupancy by inhabitants, tourists, students, workers, and other user profiles. Resilience of the Built Environment and human preparedness are two issues that have been addressing by really recent research and technical activities. Apropos, the objectives are to forecast and assess risks as well as to provide mitigative measures, including training programs for expert and non-expert people. In Risk management, communication is a fundamental step to reduce negative consequences of disasters. This is due to twofold purposes: 1) notifying those characteristics of the Built Environment that influence the mitigative/pejorative effects of hazard occurrence and 2) specifying safe behaviours to enhance users' knowledge and awareness, in order to be prepared to hazard occurrences. However, the latest scientific studies highlighted how the use of Digital Models, structured in info-graphic and parametric data, can support both the specific risk assessment and the fostering of risk communication, involving technical and common urban users. Digital Models for the risk assessment of Built Environment are part of current studies in the BE S2ECURE project. Here, the identification of a double level of training (technical and pervasive) supported by Digital Models aims at supporting risk analysis and user awareness. In detail, the Technical Model results from interdisciplinary analysis based on multi-risk (Sudden and Slow Onset Disasters) data collection in order to study potential risks in the Built Environment; on the other hand, the Pervasive Model collects results of technical assessment and proposes structured information for user preparedness to risk. In this setting, the paper introduces the methodological framework for the creation of Technical and Pervasive Models underlying the respective goals within risk management and the first outcomes of its application to two selected case studies.

CODE 332

**OUT-OF-PLANE FAILURE RESISTANCE OF ADOBE FACADES IN CUENCA -
ECUADOR FOR DIFFERENT SEISMIC ACCELERATIONS**

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KEYWORDS: Adobe; Seismic vulnerability; Demand; Capacity; Mechanism.

ABSTRACT

A considerable amount of the world's population lives in houses built with raw earth, using different techniques such as adobe, mud, bahareque, cob, etc. This research studies buildings built with adobe located in the city of Cuenca - Ecuador, which since 1999 is recognized by UNESCO as a World Heritage Site. The buildings studied have different geometric and material configurations, but all have adobe-bearing walls. This article performs an analysis of the seismic vulnerability of the adobe facade walls. The study considers 45 buildings with one and several floors, studying the behavior before out-of-plane loads and for five different failure mechanisms for different seismic intensities. The behavior of the facade walls is analyzed under the capacity - demand methodology, in which an analysis of the main factors that determine the operation in the event of an earthquake of a certain magnitude is established. As a main result, this procedure has made it possible to establish a classification of buildings according to the degree of seismic vulnerability, in addition to establishing the influence of certain parameters on the variability of seismic vulnerability.

CODE 336

**EFFECTS OF THE 1755 LISBON EARTHQUAKE ON RIVERS AND
CORRESPONDING COMPARATIVE PROPOSAL ON INTENSITY SCALE**

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KEYWORDS: 1755 Lisbon earthquake; Modified Mercalli Scale; Scale of intensity; European Macroseismic Scale; Rivers.

ABSTRACT

Records on historical earthquakes represent an important source of essential information for the analysis of earthquakes of greater intensity, which occur at intervals of decades or hundreds of years and, for this reason, knowledge only supported by instrumentation since 1980, has gaps. For this reason, despite all scientific advances, the qualitative assessment of the phenomena resulting from earthquakes is a complementary tool used by the scientific community, being the Modified Mercalli Scale (IMM 1956) and the European Macroseismic Scale - EMS-Annex 7 (1998) the most recognized, with the Environmental Seismic Intensity - ESI 2007 and the 2019 review with new data to be considered. However, these still present gaps regarding descriptors and intensity scales for rivers. This investigation analyzed the records of the 1755 Lisbon earthquake for regions bordering rivers, Zêzere, Vouga, Caima, Nabão, Cértima, Águeda, Alfusqueiro, Tejo, Alcobaça, Lis, Unhais, Serra, Alva, mapping them and presenting a proposal for descriptors and scale of intensities, in a comparative process between the different effects recorded, either in buildings or in hydrology and hydrogeology. The mapping of the phenomena allowed us to verify that most of them are located in regions along the Porto-Tomar tectonic fault, making some derivations, eventually with the direction of other probable faults. It is also along this north-south direction that most cases of abnormal movement of river water occurred, as in the region of the Caima and Zêzere rivers.

This research presents a comparative chart between the different scales and the authors' proposal, demonstrating the agreements and divergences between them, as well as the need to include greater detail for intensity degrees below X for rivers. This investigation presents a contribution of descriptors and degrees of intensity for rivers, for an eventual addendum to annex 7- EMS-98: Flow increase with possible alterations in the river course limit – between VI and VIII; Flow suppression and eventual reset - VIII or higher; unnatural current agitation, possible vertical wave movements – between VI and VIII; Stream with cloudy water – between VI and VIII. It also reports the effects of seiches and sloshing for future analysis in this framework.

CODE 48

REGULATION AND STANDARDIZATION ON THE QUALITY OF THE INDOOR ENVIRONMENT APPLICABLE TO KINDERGARTENS AND ELDERLY CARE CENTERS: PORTUGAL - BRAZIL

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KEYWORDS: Nurseries; Child Day Care Centers; Indoor Air Quality; Hygrothermal Comfort.

ABSTRACT

When assuming the importance of obtaining an adequate quality of life inside buildings, the study of the Quality of the Interior Environment assumes a very significant challenge when analyzed, mainly, in buildings that encompass a more sensitive and susceptible type of occupants, such as this is the case for children and the elderly.

In order to maintain an adequate indoor environment for the occupants, with acceptable levels of air quality and hygrothermal comfort, it is necessary to satisfy a set of requirements, namely the limitation of the concentration of indoor pollutants and the hygrothermal comfort conditions at regulated and recommended reference value ranges.

This article aims to support the evolution of design criteria in Portugal and Brazil using a comparative analysis of the regulation and standardization on Quality of the Indoor Environment applicable to kindergartens and elderly care centers. The comparative analysis intends to analyze, in particular, the following environmental parameters: air temperature, relative humidity, concentrations of carbon dioxide and total volatile organic compounds and fresh air flows.

With regard to buildings and spaces, it is intended to analyze some parameters that may have an influence on the Quality of the Interior Environment, such as: thermal transmission coefficient of the opaque vertical envelope and glazing [U], solar factor of glazing [g], façade sound insulation [D2m, nT, w], Illuminance [Em] and areas of spaces.

As an example, some measurements carried out in buildings in two cities in the interior of central Portugal, Viseu and Covilhã, are presented.

Based on the comparative analysis, some recommendations are proposed, namely in terms of the building envelope requirements, in order to obtain a general improvement in the Quality of the Indoor Environment.

CODE 184**PRESERVO - COMPLEX OF FIOCRUZ COLLECTIONS: PATH OF A
CULTURAL HERITAGE PRESERVATION STRATEGY****Pinheiro, Marcos José de Araújo^{1*}; Coelho, Carla²**

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KEYWORDS: Cultural assets; Integrated management; Integrated conservation; Cultural policies.

ABSTRACT

Created in 1900, Fundação Oswaldo Cruz – Fiocruz (Brazil) is dedicated to research, technological development, education and reference services and assistance to public health. Fiocruz created and preserves significant architectural, urban and archaeological, archival, bibliographic, museological and biological collections. These cultural collections were constituted and are preserved independently by different institutional custodian units, denoting the need to establish normative guidelines and an integrated management, which led the institution to conceive and implement, from 2008 onwards, the 'Preservo - Complexo de Acervos of Fiocruz'. The Preservo establishes the general principles and guidelines for the preservation actions to be developed for the institution's different cultural assets. It works as a network formed by the institutional units responsible for the cultural assets with the objective of establishing an integrated management, acting as a consultative instance, formulator of preservation and access actions, and responsible for articulating and guiding the implementation of its preservation policy. Preservo led to the creation of research and working groups for the development of preventive conservation and risk management plans; it is articulated with the Professional Master's in Preservation and Management of the Cultural Heritage of Science and Health, from Casa de Oswaldo Cruz/Fiocruz; has been coordinating the construction of a network of conservation and restoration laboratories and the creation of a network of digitalization platforms for collections and digital preservation structures; and guides the requalification plan for the institution's original architectural core. The work analyzes the trajectory of constitution and implementation of Preservo within Fiocruz and its possibility as a strategy and model for other similar institutions.

CODE 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****Kirk, Mark¹; Pesce, Giovanni²**1: Department of Architecture and Built Environment
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Northumbria Universitye-mail: giovanni.pesce@northumbria.ac.uk**KEYWORDS:** Regulatory Reform (Fire Safety) Order 2005; Relevant floor heights; The Building Safety Bill 2020; The Fire Safety Bill 2020.**ABSTRACT**

This paper analyses the relationship between the final floor height of existing buildings and the related means of escape from fire, to assess the potential fatality risk in low rise domestic dwellings. Aim of this research is to improve rehabilitation measures, as well as maintenance and management strategies of existing buildings. Recent UK Government guidance has focused on high rise residential buildings following the Grenfell Fire disaster that occurred on the 14th June 2017 and was reported by all main international media. In such occasion, a fire started in a tower block of flats in North Kensington, West London (UK) and led to the death of 72 people. This tragedy highlighted serious failings of the regulatory system in England. As a consequence, the UK government is introducing far reaching regulations to improve building and fire safety, so that people will be and will feel safer in their homes. Part of these regulations, however, focus on 'higher risk buildings' which is any building that is at least 18 metres or 6 storeys tall and contains either 2 or more dwellings or student accommodation. Consequently, little attention is paid on the potential risk for domestic buildings with less than 6 stores where fires can still lead to high fatalities. This paper provides an overview of the literature available on the topic, including the statistics associated with fires in domestic buildings, the recent UK Government guidance on fire safety to buildings, the Regulatory Reform (Fire Safety) Order and compliance. Primary research is based on data for existing and proposed UK Government guidance on the fire safety of occupants in domestic buildings, and data on fire incidents in domestic dwellings in The London Borough of Lambeth. Analysis of data from London Fire Brigade Incident Reporting System demonstrated that the height of a residential building does not always influence the fatality risk associated with building fires.

CODE 393

**IN-PLANE STRENGTH OF MASONRY PANELS REINFORCED WITH
INORGANIC-BASED SYSTEMS: NOVEL DESIGN-ORIENTED FORMULAS**

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KEYWORDS: Fabric reinforced cementitious mortar; Composite reinforced mortar; Inorganic composite mortar; Shear strength; Design-oriented model; Masonry; Composites.

ABSTRACT

In case of masonry walls, effectively connected each other and/or to the horizontal diaphragm, a common failure is the in-plane diagonal cracking due to the seismic action. The plastering by means of new material is commonly adopted in order to improve the shear strength of the masonry, which is generally poor because of the negligible tensile strength in the mortar joints. Among the other, the use of composite systems was largely considered in the last decades. Firstly, the Fiber Reinforced Polymers (namely FRPs) were experienced and, later, the Inorganic Mortar Composites (namely IMCs) were growingly well-thought-out as a valid alternative. In fact, IMC demonstrates an improved compatibility with the historical masonry with respect to the FRP, mainly from the breathability point of view.

The larger knowledge of the FRP-behavior produced many analytical models able to accurately predict the shear strength gain provided by the reinforcement. On the other side, the current state-of-knowledge regarding the IMC is more limited. In fact, Fabric Reinforced Cementitious Mortar (i.e. FRCM) and Composite Reinforced Mortar (i.e. CRM) are both in the IMC-family. The former involves a dry- while the latter a pre-impregnated fabric within an inorganic matrix. The available analytical models, forecasting the IMC shear capacity, are essentially based on the FRP's theory. For this reason, the present research aims to propose new design-oriented empirical formulas calibrated with an available dataset of IMC-shear-wall experimental results. The novelty consists in the definition of the contribution of the strengthening mortar with respect to the masonry shear strength gain.

2.- PROJECT

2.1.- THEORETICAL CRITERIA OF THE INTERVENTION PROJECT.

2.2.- TRADITIONAL MATERIALS AND CONSTRUCTION METHODS.

2.3.- NOVELTY PRODUCTS APPLICABLE AND NEW TECHNOLOGIES.

2.4.- SUSTAINABLE DESIGN AND ENERGY EFFICIENCY.



CODE 124**INDICATORS FOR THE PRIORITISATION OF INTERVENTIONS IN HISTORIC ARCHITECTURAL HERITAGE: AN APPROACH USING THE HYBRID DELPHI-AHP METHOD****Parra, Jaime^{1*}; Lombillo, Ignacio²; Ribalaygua, Cecilia³**

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KEYWORDS: Built Heritage; Delphi Method; AHP; Indicators System; MASPI.

ABSTRACT

Built heritage conservation reflects the maturity of a society, not only as an act of preservation of cultural identity, but also as an act of environmental awareness, so guaranteeing its protection must be a primary task. The subjectivity with which a heritage asset is recognised, and the difficulty in distinguishing the factors that threaten its preservation, are two major obstacles that can be overcome by using indicators; using them as a tool to determine the magnitude and seriousness of the phenomena of deterioration, it is possible to determine the urgency of intervention of a monument. Based on this premise, was developed a method of selection and weighting of indicators that takes advantage of the best of two methods of multi-criteria decision making (MCDM); with this fusion, a hybrid method was conceived, whereby data acquisition is carried out in a structured, repeated, and anonymous way; the information provided by a group of experts is combined into a whole, in which the results can be verified mathematically. The set of indicators obtained will be used in a system for prioritising interventions on the historical architectural heritage.

CODE 165**CARLO SCARPA AT THE QUERINI STAMPALIA PALACE.
A STUDY OF THE RELATIONSHIP BETWEEN OLD AND NEW****Bosch-Roig, Luis¹; Marcenac, Valeria²; Bosch Reig, I³; Ballester-Bordes, M.J.⁴**

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KEYWORDS: Architectural Heritage; Architectural Refurbishment; Relationship between old and new; Carlo Scarpa; Querini Stampalia.

ABSTRACT

The architect Carlo Scarpa could easily be considered as the master of the 20th century in intervention on heritage. His work presents a huge formal and material complexity. Its architectural language based on the decomposition of elements following complex geometric relationships, makes its architecture a pleasure for the senses for those who visit it. The experimentation of the scarpian architectural space produces in the visitor an enchantment generated through every detail, that accompanies him in the journey. But at the same time, this complexity turns the study of his work into a difficult process, in which it is easy to fall into the trap of language and end up trying to decipher the rule that explains the infinite ornamental sets, instead of trying to abstract those fundamental concepts that can be transmitted and thus contribute to future knowledge.

This article seeks to extract some of the keys that allowed Carlo Scarpa to carry out the exquisite intervention at the Querini Stampalia in Venice. In the first place, analyzing the transformations that he makes on the preexisting building, and secondly studying the logic of his new contributions in the rooms of the old palace. This study seeks to learn from the grand master the criteria for the relationship between old and new, in such a way that they can be transferred to future interventions in architectural heritage.

CODE 320**THE EFFECTS OF THE EARTHQUAKE OF SEPTEMBER 19TH, 2017 ON THE
RELIGIOUS HERITAGE IN MORELOS AND PUEBLA: DAMAGES AND
INTERVENTIONS****Tepox, Nayde***

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KEYWORDS: Heritage; Architectonical heritage; Conservation; Eartquake.

ABSTRACT

Earthquakes represent a latent danger for the cultural heritage in Mexico due to the nation's territory soil characteristics. Those natural phenomena have affected the country, and they will continue to strike. Although earthquakes have a cyclic behavior, they are unpredictable. Not only when and where they will take place is unknown, but also the quake's magnitude and catastrophes that they leave. Conservation of cultural heritage has a different meaning when as a result of a destructive event, it pursues the recovery of a former state and preserves the original function. As a part of more extensive research about the effects of the earthquake of September 19th on the architectonical religious heritage in Puebla and Morelos, this article aims to illustrate different ongoing preservation actions on this building heritage with several damages caused by this earthquake. These states have various religious buildings, cataloged as historical monuments with national and international declaratories. Furthermore, they have low-category buildings that are valuable because of their current use and meaning for the community and still represent a symbol of social integration. Through several visits in those areas, this article mentioned only 4 cases to exemplify the intervention resulting from this earthquake. Consequently, heterogeneous applications of conservation criteria were identified, such as reconstruction and contemporary interpretations and its counterpart the inaction as a position of earthquakes effects in the architectonical religious heritage. To demonstrate that despite the new discourses and extended heritage concepts, there is still a discrepancy between monumental architecture and others considered less critical.

CODE 375**TRADITIONAL ANDALUSIAN ARCHITECTURE. ACTIVE PRESERVATION OF THE PATIO HOUSE: TYPE, TECHNIQUE AND PROJECT**

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KEYWORDS: Traditional architecture; Seville; Typology; Patio house; Active conservation.

ABSTRACT

The research falls within the context of the recovery and regeneration of the predominantly residential building tissue in consolidated urban contexts which, subject to a continuous process of modification, are characterized in terms of a palimpsest. The goal is to re-read this transformative process and identify the codes that have regulated it in order to ensure its continuity through active conservation interventions on the building tissue that ensure its protection on the one hand and regenerative recovery on the other. The relationship between type, technique and project is assumed as the operational key of a methodology that seeks the definition not only of the qualitative parameters attributable to the recognition of the peculiarities and the complex of values of the historical building heritage and to their translation in a critical-interpretative key in the levels of transformability, but also of those of a quantitative type, referable to the performance levels connected to a necessary adaptation to new needs.

The paper intends to report the results of the experimentation of the research work, conducted in the framework of collaborative relationships with the University of Seville, on an old traditional Andalusian patio house located in the historic center of Seville, in Calle San Vicente 24.

The building has its first testimony in the Sevillian Municipal Archives in 1929; it is then the subject of various interventions up to that of 1952 by the Regionalist architect Antonio Delgado y Roig, through which the patio house finds its own precise conformation. In the nineties this was transformed into a sort of convent and later definitively abandoned.

The experimentation of the project, starting from the framework of the needs posed by the new owner, the Cultural Foundation "Centros de Estudios Andaluces", seeks a model of use compatible with the characteristics of the type, investigated in the complex of its functional, formal and constructive aspects and defines congruent intervention strategies. The design intentions are finally translated into technical-construction choices that find precise and punctual detailed solutions within the building schedule according to technical codes referable to a form of advanced craftsmanship, both in the use of traditional and innovative materials.

CODE 398**RESTORATION AS AN ARCHITECTURAL DISCIPLINE AND ENGINE OF A
NEW ELEMENT OF LIFE. THE TOWER OF ST. MARÍA MAGDALENA'S
CHURCH****Rodríguez Cantalapiedra, Pedro^{1*}**

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e-mail: pedro@pedrorcantalapiedra.es, web: <http://www.pedrorcantalapiedra.es>**KEYWORDS:** Heritage; Restoration; Tradition; Construction techniques; Materials.**ABSTRACT**

The article describes the theoretical basis of the architectural restoration processes, the phases followed in the search and documentation process and we complement it with the practical application of what has been learned in that process, explaining the fundamental bearings of the work done after the research.

The intervention in Sta. María Magdalena's church aims to recover and improve the tower and the immediate areas due to its deterioration and also to value the building, chord to its monumental condition. This research began analyzing the previous historical, archaeological, petrological and photogrammetric studies, justifying theoretically the action that will be done later. From all these studies, enough information was extracted to identify the problems, classify them according to their nature and make a diagnostic that will serve to propose the best architectonic response. Considering the intervention criteria, the necessary works for the restoration were: reconstruction, recovery, reform, consolidation, protection and improvement of the various construction system.

The methodology used to find the objectives of the project was based on a research process and documentation on techniques and materials that characterize the constructive tradition of the geographical area, important to preserve the heritage. In addition, each part of the intervention was distinguished by classifying it as repair, replacement or addition, to let constancy of every constructive contribution.

The scope of analysis carried out is reflected in the project and work, ensuring that the results obtained are provided with great sensibility protecting the historical memory through the different works carried out: existing coatings of the vaults, brickwork of tejar, facade area of mortar and lime plaster of the surfaces; the use of elm wood as a local material, in platform and carpentry, are local techniques used. The use of granite and quartzite from the rivers basin that meet in Matapozuelos (Adaja and Eresma), is a geographical identity. In addition, other materials inherent to the restoration history, are valued, such as lead, copper and alabaster.

CODE 29**BUILDING CONSTRUCTION AVANT-GARDE IN ITALIAN IMPERIALISM: AN
ARCHITECTURE AND TECHNICAL LABORATORY****Pagliuca, Antonello¹; Trausi, Pier Pasquale²; Gallo, Donato³**

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KEYWORDS: Colonial architecture; Building construction; Modern architecture.

ABSTRACT

The Italian national identity is highlighted also in the colonies, however today the urban plans and architectures are still unknown. These are an important and not insignificant architectural heritage, as they are examples of the politics and culture of the Italian “Koinè”. Many funds were allocated for the realization of these magnificent projects in the colonies; the idea was to build the “New Italy”, especially in some governorates such as those of the Horn of Africa. The ability of designers and industries to use new construction systems for colonial buildings is also interesting. In addition to traditional materials, modern building materials (steel, concrete, etc.) were imported from Italy; studies were conducted to use local natural resources to create new materials and construction techniques. Therefore, the idea of building prefabrication was developed to create “cheap” and “light” buildings that could be dismantled and easily built anywhere. The research aims to demonstrate how, only through the knowledge of these building systems and the materials of the colonies it is possible to protect this cultural heritage. This heritage, in fact, is the testimony of the industrial and design skills of “made in Italy” to create a new modern Italian architecture.

CODE 43**DECIMONONIC WOODEN BRIDGES IN THE CENTRAL REGION
OF THE COLOMBIAN ANDES****Galindo-Díaz, Jorge^{*}; Escobar-García, Diego²; Flórez, Gilberto³**

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e-mail: gflorezr@unal.edu.co**KEYWORDS:** Assembly carpentry; Wooden bridges; Vernacular architecture.**ABSTRACT**

This communication describes and analyzes, from a technical-construction point of view, a set of wooden bridges built in the central region of the Colombian Andes by craftsmen, during the second half of the 19th century, along a route called "Camino de La Elvira", between Manizales and Bogotá. From a methodological point of view, an architectural survey of at least seven of these structures was carried out over a period of twenty years, before their complete disappearance; additionally, the research was supported by first-hand documentary material (particularly construction contracts and traveler's stories as well as a few photographs) as a contrast tool; in a recent phase, the bridges were digitally reconstructed using computer tools. The results obtained have made it possible to identify the types of local wood used, as well as details of the joints of the pieces and technical resources used in their construction and maintenance phases. The conclusions lead us to think that this local tradition may well have developed from European engineers (mainly English and German) who came to the region in order to work in the region's gold mines and who, by virtue of their knowledge, contributed to the training of local labor.

CODE 94

EXPERIMENTAL STUDY OF THERMAL AND ACOUSTIC PERFORMANCE OF RAMMED EARTH PANELS LIGHTENED WITH ANGUSTIFOLIA KUNTH BAMBOO TUBES

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KEYWORDS: Angustifolia Kunth; Lightened rammed earth; Thermal behavior; Airborne noise.

ABSTRACT

This research studies the interaction between ecological materials, elaborated with techniques of low environmental impact. The properties analyzed are related to thermal and acoustic behavior. In this way, a procedure of lightening rammed earth walls made with raw earth is proposed, replacing mass or void material in the earth-made panel by an organic material. For the experimental study, to reduce the volume and weight of the traditional solid wall, an organic and sustainable material such as bamboo (*Angustifolia Kunth*) is applied. In this way, three types of wall were elaborated, all of them conserving a thickness of 20 cm, placing internally in serial disposition, the lightening system conformed by bamboo tubes of 60 cm long with external radius of 6 cm to 7 cm. In this way, tapial wall modules were elaborated, varying the reduction of mass or lightening between 0% and 11%, percentages that ensure the preservation of the normal mechanical characteristics of the tapial. The samples allowed the study of physical properties such as heat conduction and airborne noise insulation, through an experimental process that allows placing the walls between two environments, an emitting and a receiving room; in this line, maintaining a constant thickness in a rammed earth wall and a reduction between 6% to 11% of mass, the tested earth walls slightly reduce their heat insulation properties, while in the case of airborne noise, the addition of bamboo as a lightening material improves the insulating properties in relation to a traditional solid wall. The results of this study indicate the compatibility of natural bamboo with rammed earth to improve the thermal and acoustic properties of wall panels made with this combination of raw materials.

CODE 105

USE OF CHALCEDONITE POWDER AS A SUPPLEMENTARY MATERIAL IN LIME MORTARS

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KEYWORDS: Chalcedony; Lime mortar; Pozzolan material; Frost resistance; Porosity.

ABSTRACT

This paper presents a study on partial replacement of lime binder with chalcedonite powder with the purpose of exploring a new application of this waste dust as lime mortar additive. Chalcedonite powder is formed as a by-product of the treatment of mined stone containing chalcedony as the main mineral. Standard air lime mortars were made by incorporating from 0% to 40% of micronized chalcedonite powder in replacement to lime and their mechanical performances, microstructure, and durability were determined. Despite the fully crystalline nature, the chalcedonite powder showed an unusually high pozzolanic activity predicting an improvement in the mechanical properties and durability of lime mortars. As the replacement level in lime mortars increased, the amount of mixing water needed for the same mortar consistency decreased, and the performance properties of the mortars improved. The increase in strengths of mortars was manifested mainly in the long term of 180 days. The progress in mortars carbonation, as well as the pozzolanic reaction of chalcedonite powder, led to the formation of denser, less water absorptive, and more frost resistant structure in air lime mortars. The effective use of waste chalcedonite powder as a supplementary material in lime mortars was assessed to enhance their performance in building practice or to prepare feebly hydraulic mortars used in the past in constructions nowadays considered built heritage.

CODE 112

USE OF FINE-GROUND LAVA SAND AS A POZZOLANIC ADDITIVE IN AERIAL LIME-BASED MORTARS

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KEYWORDS: Lime mortar; Pozzolan; Fine-ground lava sand; Durability; Salt crystallization; Microstructure.

ABSTRACT

Pozzolanic additives were historically used in the construction practice to ensure improved mechanical properties and durability of the predominantly aerial-lime based mortars for the highly-stressed applications such as bridges, piers etc. The paper addresses the use of fine-ground lava sand as pozzolanic additive in aerial lime-based mortars. The mortars with 10%, 20%, and 40% lime replaced by the ground lava sand are studied regarding their strength properties, microstructure, and durability to freezing-thawing cycles and salt crystallization. The incorporation of ground lava sand to the mortar mixture leads to increase in strength by up to 50% in later ages. The pozzolanic reaction of the ground lava sand and lime along with the decrease in amount of aerial lime and kneading water in the mixture results in more unimodal pore distribution with lower total porosity, thus also lower water intake under atmospheric pressure. This change in microstructure combined with increased strength leads to mortars with improved durability to both, salt crystallization and freeze-thaw cycles. The fine-ground lava sand is found to be a suitable additive for aerial lime-based mortars to enhance their performance in building practice or to prepare mortars imitating the feeble hydraulicity of limes used in the past in constructions nowadays considered built heritage.

CODE 123

CONSTRUCTIVE TYPOLOGIES ON PREHISPANIC STONE WALLS IN THE REGION OF PUNO, PERU

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KEYWORDS: Construction typologies; Stone structures; Prehispanic; Puno; Peru.

ABSTRACT

Today, a large part of the historical stone structures belongs to the cultural heritage of each country. Then, it is important to maintain and preserve these constructions over time. These structures can be very simple or extremely complex depending on their way of construction. In Peru, most of these constructions do not have the same standard typology due to the great historical and cultural diversity. In this research, a detailed evaluation of the typologies of six prehispanic stone walls in the region of Puno is done. In each archaeological site, the stone-walls are analyzed according to their main function, their global shape, their number of leaves, their internal filling and if they have mortar or not, and the rocks according to their size, condition and other characteristics. As a result, a database of the typical construction typologies of the prehispanic period in the Puno region is presented. The purpose of this taxonomy is to describe and classify prehispanic walls in a uniform manner as a key step towards assessing their structural behavior.

CODE 167

ADVANCED TECHNOLOGIES FOR NATURAL STONE | INOVSTONE 4.0 - IMPORTANT RESULTS FROM A RESEARCH PROJECT ON NATURAL STONE CONSTRUCTION MATERIALS SELECTION AND PERFORMANCE ANALYSIS

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KEYWORDS: Building materials; Portuguese Natural Stones; Physical-mechanical and geochemical characterization; Thermal ageing.

ABSTRACT

The natural stone as a building material has been revealed to have much lower life cycle costs than other materials as concrete, glass and steel. For this reason, it has a positive impact on the environment. However, several incidents with different pathologies on distinct lithologies has led to an increase in maintenance costs. The lack of knowledge on a stone performance over time and the frequent absence of a solution has a significant negative effect on the entire stone trade. Therefore, less sustainable, and less durable construction solutions are used as an alternative. The work-package “Tools for value” of the Inovstone 4.0 project (Advanced Technologies and Software for Natural Stone) addresses the need to highlight the dynamic capacity of the Portuguese Ornamental Rocks Sector (RO) based upon in-depth knowledge on natural stone performance regarding dissimilar testing conditions and, at the same time, strengthen its competitiveness in relation to the new digital procurement model, namely in the context of the Building Information Modeling (BIM). This paper provides a comprehensive overview of the main project findings. The main objectives were: i) Classifying the stones by petrographic, mineralogical and geochemical analysis; ii) To understand and explain the mechanisms of the loss of strength caused by thermal ageing cycles; iii) To study the effect of biodeterioration on marbles, slates and limestones; iv) To develop a concept for assessment of Portuguese natural stone products, including a monitoring system to predict strength development and improve safety and reliability; v) To address quality control issues to optimize the production conditions. The research was performed on twenty-five different lithotypes, from various locations in Portugal. Project results eased the development of Portuguese natural stone construction products selection, performance guidelines and critical influence factors. Biosusceptibility and colour evaluation have been performed in the laboratory and revealed crucial results, including the suitability under certain environments, potential durability, and cleaning ability after exposure. Guidelines for selection and product control have been proposed and developed aiming at natural stone construction products with improved service life.

CODE 185**HISTORICAL HOSPITALS IN NAPLES: ENHANCING CONSTRUCTION TECHNIQUES AS A STRATEGY FOR POTENTIAL URBAN REGENERATION INTERVENTIONS****Sicignano, Claudia^{1*}; Diana, Lorenzo²; Marmo, Rossella³; Polverino, Francesco⁴**

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e-mail: polverin@unina.it**KEYWORDS:** Resilience; Preservation; Historic hospitals.**ABSTRACT**

The historical hospitals of Naples represent a significant heritage section of existing buildings. The city is an important case study, not only for the quantity of monumental hospital structures in the urban context, but for clear characteristics that define their values, from the artistic-cultural richness to the typological and constructive quality. Above all, from the construction point of view, the methods originally used to build these health structures are representative of traditional Neapolitan building techniques and essential starting points when considering sustainable regeneration interventions. This paper analyzes the traditional construction techniques of selected historical hospitals in Naples. The technological characteristics and structural systems of two emblematic case studies are examined with the aim of identifying relevant strategies for sustainable and effective regeneration interventions. The results show that the knowledge of traditional construction techniques helps to select appropriate regeneration solutions.

CODE 193**STRUCTURAL ANALYSIS FOR CONSTRUCTIVE HYPOTHESIS OF THE
ANNULAR VAULT OF CARLOS V PALACE IN GRANADA (SPAIN)****Puertas, Esther¹; Gallego, Rafael²**

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KEYWORDS: Toric vault; Constructive hypothesis; Finite element method; Masonry.

ABSTRACT

The annular vault of the Palace of Charles V is one of the most unique structural elements among the masonry constructions due to its double curvature and the existence of a vertical axis of revolution that make up a self-stable structural system in its final configuration. The construction of this element is critical since before it is completed, requires the use of auxiliary means to guarantee its stability. Previous studies, based on ocular inspection and the study of historical documentation, have proposed a construction process consisting of the initial construction of the circular ring on the interior columns, followed by the placement of equidistant props working in compression and finally the construction of successive sections of the vault on movable wood formwork until the vault is closed. This study presents the results obtained after carrying out a numerical analysis of the assembly in the different phases of the construction process, established to evaluate the validity and viability of the described construction hypothesis. In this way, a three-dimensional model of the structure has been developed in different construction phases, from the placement of the first vault sector to its closure, considering in each case the existing loads due to the own weight of the elements and analyzing the stresses and deformations produced, as well as the structural stability. The study is also completed by obtaining the ultimate collapse load in each phase. The results obtained show that the construction process analyzed is structurally viable, in which the thrusts of the vault are absorbed externally by the perimeter wall and internally by the circular ring on pillars, which works in compression and whose integrity and stability during the intermediate phases is guaranteed by the work in compression of the struts located in the positions where the vault is not yet built. Moreover, in general, this study shows the usefulness of the analysis of the structural behavior for the validation of constructive hypotheses in singular historical buildings.

CODE 224

THE “ORO NERO” IN THE ARCHITECTURE OF THE THIRTIES IN SOUTHEASTERN SICILY. MEANINGS AND IMITATIONS OF A LOCAL MATERIAL

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KEYWORDS: XXth century; Italian architecture; Modern; Autarchy; Asphaltic limestone.

ABSTRACT

During the Thirties, the autarchic policy of the fascist regime influenced the architecture and construction fields. The research of a modern style sought a compromise within the necessity of recovering the traditional construction techniques and the local materials' utilisation. The architecture became the propaganda vehicle of the regime's nationalist ideals, presenting, at the same time, common stylistic features and an accentuated localism strongly related to traditional contexts and productive areas. In Ragusa, the new province chief town since 1926, the growing industrial exploitation of oil fields, to produce fossil fuels, became of national economic relevance, also determining the recovery of the so called “oro nero” as a distinctive construction material which characterized southeastern Sicilian regime architecture.

The asphaltic stone, a brownish-grey bituminous limestone quarried on the Monti Iblei, is characterized by the ease workability in blocks or slabs used for the realization of decorative apparatuses, sculptures, interior and exterior flooring. Its systematic diffusion in architecture began after the Val di Noto earthquake in 1693 and, since then, it was used always in association with the local whitish limestone (Pietra di Noto-Pietra di Comiso), determining the characteristic bichromy of the hyblean architecture. Piazza Impero in Ragusa (nowadays Piazza Libertà), testimony of the ambitious and celebrative architectural program of the regime, was the main gathering place where, between 1933 and 1942, all the buildings of the party were built: the Casa del fascio e del balilla, by arch. Ernesto Lapadula, the Casa del mutilato e del combattente and the Palazzo provinciale dell'Economia, by arch. Francesco Fichera. The purpose of this study is to investigate and illustrate the renewed use of the asphaltic stone as a cladding material and the use of bitumen – industrially extracted from it – as a surface finishing product, applied through impregnation on the white limestone of the façade of the Casa del fascio e del balilla, so to imitate the chromatic appearance of the asphaltic stone. To date, this is the only 20th century built example in Ragusa where it has been documented this particular use, partially lost during the last cleaning intervention of the facades (2012).

CODE 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**

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KEYWORDS: Royal Alcazar of Seville; Islamic plasterworks; Execution/construction systems; w/g ratio; Porosity.

ABSTRACT

The Royal Alcazar of Seville (hereinafter the "RAS") boasts a very diverse range of plasterwork dating from different periods (14th-16th centuries). This study examines the physical-mechanical properties of the material (porosity, apparent density, water/plaster ratio and surface hardness) conditioned by the construction or execution techniques used, in order to obtain a better understanding of these techniques and to establish a sequence of tests to facilitate the identification of the system that may have been used to produce each element.

The aim was to establish a simple methodology to complement historiographical studies and visual inspections in order to evaluate the execution technique used in the creation of the plasterwork. The study of the elements at the RAS can be extrapolated to plasterwork in other similar constructions.

The model was based mainly on the establishment of mathematical ratios between the properties to identify the techniques most commonly employed: carving or modeling and molding. The water/plaster ratio (w/p) used determined the setting time and ranges of values obtained for apparent density (1.38-1.03g/cm³), porosity (41.9-56.5%) and Shore hardness (60-81). It was concluded that hardness, which was the property that provided the most reliable information for identifying the construction system used and its determination, required a non-invasive non-destructive technique.

CODE 337

REHABILITATION OF EARTHEN ARCHITECTURE, FROM COURTYARD HOUSES TO BRAZILIAN HOUSES IN THE CENTER OF PORTUGAL

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KEYWORDS: Rehabilitation of buildings; Earthen architecture; Mechanical characterization of materials; Chemical analysis; Adobe.

ABSTRACT

In Portugal, the successive economic crises affected the construction market, with a decrease of 77% of buildings completed in the last 20 years. The construction crisis resulted in the loss of technicians and skilled workers, affecting above all the rehabilitation of the old buildings, which in 2011 represented only 5.8% of the total building stock. This study recorded representative buildings of Earthen Architecture, such as the Gandaresas courtyard houses (1164 buildings) and the Brazilian type houses (462 buildings) in 10 municipalities in the Center region of Portugal, presenting a characterization of their architecture. Given the predominance of adobe in this region and in this type of buildings, research has been carried out based on laboratory and in situ tests for the material and mechanical characterization of adobes, but also of the mechanical behavior of adobe masonry, which is important to validate options for rehabilitation.

From the survey of anomalies carried out in situ, it was possible to conclude that most of them result from long periods of abandonment or the inexistence of timely repairs. These include roof infiltrations impacting the structural safety of roof timber structures and floors. Consequently, the lack of connections and bracings due to the degradation of the wooden structure increases the probability of deformation of the walls and their out-of-plane movements. These more frequent causes of damage are not associated with normal degradation processes and are preventable. The other major causes of damage are human action, namely alterations without technical monitoring, rehabilitation without knowledge of the specific characteristics of adobe masonry, with the introduction of incompatible materials and solutions.

This research took specific regard the contribution to conservation strategies, providing the values referred to material characteristics and mechanical behavior which can be used in the development of numerical models that will make it possible to demonstrate that in most situations these constructions are prepared to resist regulatory actions. These values are fundamental to verify the safety of the masonry in the plan, and bracing measures should be taken to improve the out of the plan behavior, mainly taking advantage of the construction's box behavior.

CODE 353**METHODOLOGY OF EVALUATION OF TECHNOLOGIES.
PROPOSAL APPLIED TO BUILDING INTERVENTIONS****Bozzo, Laura^{1*}**

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Other members of the Equipo de Evaluación de programas y de tecnologías para la vivienda social: Lucía Abbadie, Horacio Álvarez, Laura Bozzo, Myrna Campoleoni, Stephanie García, Virginia Martínez, Fernando Roa, Susana Torán

KEYWORDS: Evaluation; Traditional construction; New technologies; Design; Heritage architecture.

ABSTRACT

This work synthetically describes the main aspects of the problem and the evaluation methodology proposed by the team from the Faculty of Architecture, Design and Urbanism - Udelar, which investigates social housing built in a traditional way or with innovative technologies. It is proposed to transfer the theoretical framework applied in this evaluation to heritage architecture or non, applied to housing, guiding decision-making at the level of project and its implementation.

The methodology used is described in its physical, economic and social aspects, the main characteristics of what was evaluated and a systematization of the results of 30 years of research and counselling, which show the importance of evaluating before so as not to have to correct later; to acquire and systematize information on what exists, focusing on the needs of the demand and not on the possibilities and interests of the supply; that technology can contribute in an important way to optimize the processes of production and improvement of homes, making a more efficient use of the resources, but that its improvement must be complemented with efficient management, both public and private, and above all with the recipient participation.

When considering the heritage building, its multiple dimensions must be taken into account, also contemplating the territorial and environmental dimension of a construction that lasts for all. It is proposed to value the importance of management as a trigger not only for notable improvements in the efficiency of what is built, but also for social processes seeking the sustainability of the transformations.

CODE 362**PORTUGUESE VERNACULAR CONSTRUCTION AND ITS SUSTAINABLE REHABILITATION CHALLENGES: THE SCHIST VILLAGES, LOUSÃ****Mouraz, Catarina P.^{1*}; Silva, J. Mendes²; Ferreira, Tiago Miguel³**

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e-mail: Tiago.Ferreira@uwe.ac.uk, web: <https://people.uwe.ac.uk/person/tiagoferreira>**KEYWORDS:** Vernacular construction; Rehabilitation strategies; Schist construction; Sustainable rehabilitation; Constructive characterization.**ABSTRACT**

The development and progress of rural territories as a vector towards achieving global development and territorial cohesion has been gradually becoming a European and international priority. The severe out-migration and desertification that these territories are experiencing are impacting their remaining population significantly. In that matter, rehabilitation actions and the improvement of living conditions can play a powerful role in avoiding or even reversing this situation.

For this purpose, it is fundamental to consider the vernacular constructions typical of rural areas and perceive their evolution throughout centuries as a testimony of wisdom and sustainable response to the context they are part of. To ensure this, the first step towards a conscious intervention consists of acquiring the deep knowledge of these buildings' characteristics and conservation state, contributing to informed decision-making processes which support the definition of appropriate case-specific intervention strategies.

This article presents an initial step towards the characterization of the Schist Villages of Serra da Lousã, located in the central region of Portugal. A historical and geographical context is presented, as well as the main constructive and architectonic characteristics of these vernacular constructions. Moreover, information is gathered concerning what is seen as the main challenges for the rehabilitation and revitalisation of these territory, presenting a SWOT analysis intended to analyse what are the main strengths, weaknesses, opportunities, and threats of intervention processes in rural areas similar to this.

CODE 363

INFLUENCE OF REGIONAL GEOLOGICAL CHARACTERISTICS ON PORTUGUESE VERNACULAR CONSTRUCTION: CASE STUDIES

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KEYWORDS: Vernacular construction; Stone Masonry; Built heritage; Construction characterisation.

ABSTRACT

During the last half-century, and especially in the last decade, current built heritage has been recognised as a fundamental part of the common heritage, with strong repercussions in places' identity and in the sustainability of development strategies.

Rural housing settlements are also in the domain of both territorial cohesion concerns across Europe and the United Nations' sustainable development goals. To guarantee its preservation and enhancement, it is required to invest in the detailed knowledge of these settlements and the buildings that compose them, which are frequently built with stone.

This article aims to present fundamental characteristics common to different types of vernacular stone masonry construction in Portugal, regardless of the area where they are located, the time of construction, and the geological characteristics of the region. This characterisation is organised around the main functions of masonry and its components.

This information is densified with the presentation of characterisation examples in four Portuguese areas where the local geology has led to the predominance of buildings built with limestone, granite, schist, and volcanic stones.

Finally, given the main vulnerabilities observed in these constructions, an exploratory framework of intervention strategies is presented, aiming to promote these constructions' identity preservation and constructive coherence.

CODE 371

EARTH BUILDINGS IN CRETE: BUILDING CONSTRUCTION KNOWLEDGE THROUGH THE DOCUMENTATION AND PRESERVATION OF EARTHEN ARCHITECTURAL HERITAGE

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KEYWORDS: Earthen architecture; Greek heritage mapping; Earth buildings in Crete; Earthen architectural heritage; Minoan clay architecture.

ABSTRACT

In this paper we present traditional and contemporary earthen constructions located in Crete. The techniques that have been used in Greece are identified, emphasizing these that are located in the island of Crete. The aim of this research is the preservation of knowledge of clay constructions, as part of Greece's cultural heritage and way of living. Major part of the research focuses on the "state of the art" of clay structures in Crete, thus setting the beginning for the historical documentation of earthen structures for the rest of Greece. The documentation of these types of buildings is crucial due to the fact that these types of structures are abandoned and need to be preserved. However, these types of earthen structures are still standing, testifying their tradition and know-how of their construction era.

The methodology applied is based both on bibliography scientific research, on recording and documenting of clay buildings in Crete through in-situ visits and on the construction of 1:1 scale test earthen structures.

The study is dealing with the tradition and the potential of earth as a building material in Greece. The tradition of the clay constructions is analyzed, starting from the first historical records of this building material in Minoan Crete until the contemporary clay buildings of the island of Crete. Case studies of buildings with natural materials are presented and analyzed in relation to the traditional knowledge of earthen techniques.

Concluding, we are focusing on the importance of preserving earthen Greek architectural heritage and building tradition. We found that contemporary clay structures are using mainly different building techniques - mostly light clay - and that the most commonly used technique of abode structures is forgotten mainly due to the lack of Greek building legislation and to deficient historical recordings of clay building techniques of Greece. Suggestions for further research in relation to earthen architecture are proposed, in order to maintain the structural and cultural knowledge that these types of buildings can transfer to the future.

CODE 41**SERVICE LIFE AND EARLY AGE DURABILITY ENHANCEMENT DUE TO COMBINED METAKAOLIN AND NANOSILICA IN MORTARS FOR MARINE APPLICATIONS**

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KEYWORDS: Sustainability; Marine Environment; Durability; Nanosilica; Metakaolin.

ABSTRACT

The addition of a range of micro- and nano-particles to high-performance concrete has been the focus of recent research. At present, studies are mainly aimed at designing customised mortars, providing them with specific properties for each application. Improving the durability of mortars is one of the main objectives in such research, as a result of increasing environmental concern. The research presented herein analyses the synergistic effect of nanosilica and metakaolin as additives on the service life of cement-based mortars subject to aggressive environments (i.e., chloride exposure) at early ages. The effects of the additives on the durability properties of submerged samples after two and three days of curing were analysed. Tests were conducted on several different properties: resistivity, porosity, mechanical properties, chloride diffusion, and service life. It is observed that metakaolin and nanosilica exhibit a synergistic effect as additives, which is related to porosity refinement and chloride ion binding capacity, which contributes to enhanced resistance against chloride penetration from very early ages.

CODE 70**SIDERURGICAL MORTARS IN SPAIN: REHABILITATION OPPORTUNITIES
AND AN OVERVIEW OF PROGRESS**

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KEYWORDS: Electric Arc Furnace Slag (EAFS); Ladle Furnace Slag (LFS); Cement and aggregate substitutions; Mortar design; Durability.

ABSTRACT

In the present paper, waste products from the steel-making industry are reused as fine raw material in rehabilitation mortars for construction works. Two cement mixes are evaluated: masonry mortars and structural mortars. The study is focused on two steel-making by-products: electric arc furnace slag and ladle furnace slag. The mortar design proposed here incorporates the former in partial substitution of fine aggregates (sand) and the ladle furnace slag in partial substitution of Portland cement and, in some cases, as aggregate (filler). Several partial substitutions of mortar binders/aggregates were prepared which yielded different mixes: 8 masonry mortars whose compressive strengths were below 20 MPa and 12 structural mortars whose compressive strengths were over 50 MPa. At the lab scale, various physical and chemical tests were performed on batches in both the fresh and the hardened state (densities, spreading, mechanical strength, porosity and weathering studies). Our results fully support the use of these siderurgical mortars for architectural (non-structural) rehabilitation purposes and in structural refurbishments for strengthening reinforced concrete elements.

CODE 71**EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF
MICROCEMENT-BASED GROUTS**

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KEYWORDS: Masonry walls; Microcement-based grout; Mechanical characterization.

ABSTRACT

Currently, grouts based on ultrafine hydraulic binder (microcement) are competing with those of hydraulic lime in the field of masonry walls reinforcement and consolidation. Due to their chemical composition, with a 75% of pozzolanic components (44% CaO y 31% SiO₂), these grouts are compatible with historic masonries, showing better mechanical performance and suitable flow characteristics to injection.

Due to its recent introduction in the masonry repair field, little scientist literature can be found over microcement-based grouts, so the main goal of this research is determining its mechanical behaviour from the obtention of properties as compression strength.

It is worth noting the little specific standards referred to grouts, which forward to mortars standards concerning mechanical testing. However, regarding grouts without sand, mixture behaviour is very different to that of the mortars even since setting process. In this research, only superplasticizer has been added to the mixture, at the rate of 5% of microcement weight.

In this paper, a review about referred standards will be exposed initially. Subsequently, the different experimental methodologies carried out for a ratio W/C=1 (mold materials and specimens size) will be shown. Finally, results obtained will be discussed and relationships between these ones and the different variables taken into account will be find.

CODE 72**LIGHTWEIGHT CEMENT COBBLE MADE WITH RECYCLED ROOF WASTES**

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KEYWORDS: Cement; Cobble; Roof wastes; Recycled materials; Sustainability.

ABSTRACT

This study analyzes the physical and mechanical properties of different precast cement cobble with the addition of industrial waste from recycled vehicle roofs, with progressive substitutions of sand for 25%, 50%, 75% and 100% polymer waste. To reduce the impact on mechanical resistance and wear resistance due to the incorporation of the waste, additives have been used to get a greater compaction of the cohesive matrix. It starts from a previous analysis in which all the raw materials used have been described and the physical and mechanical properties presented by the mixtures with the incorporation of this roof wastes have been analyzed.

This seeks to reduce dependence on raw materials and reuse waste, following the European, national and regional programs that lead to new techniques for the recovery of waste in the production of construction materials.

Cement cobble with commercial dimensions have been manufactured complying with the minimum values required by the regulations to carry out the corresponding tests, analyzing the total water absorption, resistance to breakage and resistance to abrasion wear of the different dosage with their corresponding percentage of waste used. The addition of the polymer waste and the inclusion of the additive generate reduced values in terms of mechanical resistance and acceptable values in terms of abrasive wear, depending on the percentage of substitution, achieving recycled low-density cement cobble and substantially reducing their weight compared to traditional products, with an improvement in its workability and compaction.

The use of this type of industrial waste can be considered for the production of sustainable materials, helping to reduce the environmental effects produced in the manufacturing processes and to reuse the waste generated in the industry, with the consequent environmental benefit that it entails.

CODE 91**CLIMATIC PERFORMANCE INDICATOR BASED ON FUZZY LOGIC:
APPLICABILITY TO THE ARCHITECTURE, ENGINEERING AND
CONSTRUCTION SECTOR****Prieto, Andrés J.¹; Carpio, Manuel^{2,3}**

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KEYWORDS: Fuzzy logic systems; Engineering and construction sector; Climate Change Performance Index (CCPI); Decision-making; Chile.

ABSTRACT

Considering the South American context and particularly the Chilean case, climatic effects and natural risks acquire a particular emphasis due to the extreme conditions in many locations. Thus, in terms of the importance of preserving the architectural heritage of our towns and cities, it is essential to develop specialized methodologies to support decision-making by professional experts in heritage conservation, especially in developing countries and also considering the effects of external hazards related to climatic and natural variables, as in the case of Chile, where there are few studies related to the preservation of local heritage including climatic variables and its current conditions, this kind of approach is essential. Hence, due to the uncertainty related to the prediction of future climate conditions, a new fuzzy inference system is proposed aimed at predicting climatological variables and their effect on heritage infrastructures. This new digital model is based on previous fuzzy systems experiences and on the analysis of an earlier Delphi study, which was carried out to explore the climatic variables in their effect on the conservation of buildings. Mainly, the new digital system based on fuzzy logic focuses for the first time on evaluating five climatic variables (precipitations, temperature, wind, solar radiation and relative humidity) regarding the preservation of buildings and considering the specific characteristics of each site. This study establishes a new fuzzy logic method, which allows a systematic classification of buildings' performance and their efficacy based on climatic conditions. The novelty of this research work concerns an original fuzzy inference system, which can model information with uncertain degrees, which should be regarded as new support for the decision-making process concerning heritage building performance and climatic conditions in South America, particularly Chile. This research provides new advances in terms of the influence of climatic indicators on the functional performance of heritage buildings. This type of work is a new contribution towards predicting the deterioration of buildings in different climatic situations.

CODE 125**FEASIBILITY OF DEFECT DETECTION IN CONCRETE CYLINDERS BY MEANS OF MUON SCATTERING RADIOGRAPHY (MSR)****Orio, Aitor^{1*}; Martínez, Pablo²; Díez, Carlos¹; Gómez, Pablo¹**

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e-mail: parbol@ifca.unican.es, web: www.cern.ch/pablom**KEYWORDS:** Non-Destructive Testing; Concrete inspection; Muon Scattering Radiography; Cosmic rays; Multiwire Proportional Chambers.**ABSTRACT**

Cosmic muons are elementary particles created in the atmosphere due to the incidence of cosmic rays. These particles reach the surface of the Earth with an approximately constant flux. Muons traverse all objects, and they can be used to create density maps of their interior especially in the case of dense and large objects. To perform a Muon Scattering Radiography (MSR), it is necessary to measure the trajectory of muons before and after crossing the target. The denser the target is, the larger the muon trajectory deviation. The main objective of this research is to establish MSR as a Non-Destructive Testing technique to test the deterioration and defects of concrete structures, where other inspection techniques are difficult or impossible to apply. MSR can detect density changes, cracks and voids in very large objects thanks to its large penetration power. In addition, this technique is fully non-destructive and can be used in applications where delicate structures are involved, such as monuments or ancient buildings, since it does not require any contact with the target. This work focuses on the study of feasibility of the detection of subtle defects in small concrete structures using MSR. Specifically, it is proposed to use muon detectors based on multiwire proportional chambers to collect the data samples. This study used unreinforced concrete cylindrical-shaped samples of 15 cm of diameter and 30 cm of height. Scenarios with different cracks are measured to show the power of the technique. A specific reconstruction algorithm which optimizes the detection capabilities is proposed. Results show that the detection and imaging of full transverse cracks of about 1 cm of aperture is possible with this technique.

CODE 157**THE BUILDING STOCK REHABILITATION: THE CONTRIBUTION OF
VERTICAL GREENERY SYSTEMS (VGS)**

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KEYWORDS: Green walls; Real estate; Sustainability; Refurbishment.

ABSTRACT

In the last few decades, the energy requalification of the building stock has seen an increase in experimentation on innovative envelopes: among these, vertical greenery systems (VGS) have taken on a certain importance. The concept of VGS has changed radically: from simple façades on which vegetation climbed to advanced skins integrated into the building envelope, in which greenery is transformed into a constructive element. VGS refers to the wide range of interventions that can be carried out on the façades of buildings, whether new or existing, which allow a greater extension of the vegetation envelope in terms of square metres, compared to the more famous green roofs. For some years now, vertical greenery has been one of the aspects of environmental sustainability both on an architectural and urban scale. Some studies highlight the advantages of using VGS, but technological solutions become particularly complex where they have to be adapted to existing buildings. A classification of the numerous solutions proposed by the construction market, with a critical evaluation of their performance, would allow professionals to select which solution is most suitable for their needs. The aim we want to pursue is the rehabilitation of the existing building stock: greenery can contribute to the quality of the settlement system, giving a signal of broad agreement with those principles of sustainability to which the environmental challenge demands adherence urgently.

CODE 166**PRELIMINARY STUDIES TO IDENTIFY SUITABLE DEMONSTRATORS FOR
RADON REMOVAL WITH INNOVATIVE PAVEMENTS**

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KEYWORDS: Radon; Heritage refurbishment; Innovative floor coverings; Indoor environmental quality.

ABSTRACT

Radonflow project aims to test several innovative technical floors and pavements for rehabilitation, which allow radon gas evacuation, preventing it from penetrating from the ground into living spaces. This work shows a preliminary method to select demonstrator buildings for testing prototypes for radon gas evacuation in historic buildings. For this purpose, several examples have been taken from the University of Alcalá, and some environmental parameters have been monitored. In addition, the existing pavements are analysed to know the possibilities of intervention and improvement. These are historical buildings to test and adapt the proposed rehabilitation solutions, logically compatible with the protection and conservation of the heritage. This has made possible to locate suitable places for the installation and testing of these innovative systems.

In the cases analysed, low radon levels have been obtained with respect to the reference levels. The most suitable case for demonstration is the basement space of the Faculty of Law.

CODE 239**EXPERIMENTATION OF NEW PRODUCTS AND SOLUTIONS AT FULL SCALE
IN KUBIK. ITS EVOLUTION AND TRANSFORMATION IN 10 YEARS OF
OPERATION****San Mateos Carretón, Rosa¹; Garay-Martinez, Roberto²; Egiluz, Ziortza³**

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e-mail: ziortza.egiluz@ehu.eu**KEYWORDS:** Experimental infrastructure; Positive energy; Energy efficiency; Digital Twin.**ABSTRACT**

For 10 years, KUBIK has been a benchmark for the experimentation of full-scale solutions, for the improvement of energy efficiency in buildings and thus be able to contribute to the generation of buildings with almost zero energy; but in recent years the product developments are oriented to the evolution of buildings of positive energy.

In addition, this experimental infrastructure has also been able to integrate digital technologies, managing to adapt to the great challenge of the digital world, becoming one of the first Digital Twin in the world in the field of building.

The architecture of this platform allows the deployment of technologies such as artificial intelligence and the Internet of Things that contributes to the advances of intelligent energy management and predictive maintenance of buildings, without forgetting the comfort and health of their users.

This article presents how the initial concept of open and versatile building has allowed to adapt to the new needs of the world context, growing in the incorporation of new renewable energy production systems and advancing in low temperature district networks.

There are more than 50 projects that have been developed in Kubik that have generated a related scientific production of more than 30 articles and four product patents.

CODE 247

REUSE OF RESIDUAL DIATOMACEOUS EARTH FOR THE PRODUCTION OF GEOPOLYMERS - A REVIEW

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KEYWORDS: Geopolymer; Diatomaceous earth; Waste valorization; Portland cement.

ABSTRACT

Issues related to sustainability and environmental impacts generated by the construction industry are increasingly discussed nowadays. Cement production, by itself, is responsible for 5% of world CO₂ emissions. Hence, it is inevitable to find an eco-friendly alternative material to the existing Portland Cement. As a consequence, investigations related on the resources and energy consumed during the construction phase and the production of cement or other materials essential for all construction, has been performed.

Based on construction typology of some Egyptian and Roman monuments, namely the pyramids of Giza and the colosseum in Rome, where natural stone, limestone and sodium, were used, studies about the application of geopolymers as a new type of agglomerate, have been performed in the last few years. Geopolymer cement is an innovative construction material prepared by using a solid precursor (aluminosilicate material) and an alkaline solution (NaOHNa₂SiO₃).

Considering the promising results obtained until now, the project “BacchusTech – Integrated Approach for the Valorisation of Winemaking Residues (POCI-01-0247-FEDER-069583)”, with funding from the “European Regional Development Fund (FEDER)”, aims to use geopolymers obtained from diatomaceous earth, valorising the winemaking waste and contributing to a sustainable construction.

Geopolymers are inorganic polymers obtained through polymerization of natural raw materials of geological origin, rich in aluminosilicates. The materials rich in silica, in this case diatomaceous earth, when in contact with alkaline solution originate a solid binder. In this work is intend to study the feasibility of using this alkali-activated binder, as the binder material for concrete.

A review of extensive studies conducted on a diatomaceous earth geopolymer concrete is presented. The paper also includes brief details of some recent applications of geopolymer concrete.

CODE 252**NUMERICAL EVALUATION OF THE STRUCTURAL CONTRIBUTION OF STRENGTHENING FOR TENSION PERPENDICULAR TO THE GRAIN AND SHEAR IN REINFORCED CONCRETE JOINTS FOR TIMBER FRAMES****Ribeiro, Aléxia^{1*}; Negrão, João²; Dias, Alfredo³**

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e-mail: alfgdias@dec.uc.pt**KEYWORDS:** Timber structures; Reinforced concrete corners; Epoxy resins; Numerical modelling; Finite elements.**ABSTRACT**

The corner joints of glued laminated timber frames may be made up with reinforced concrete, the reinforcement bars being bonded into the two timber elements with a structural anchorage epoxy resin. This type of connection aims at providing resistance to bending moments with no need for steel plates and fasteners and duplication of one of the timber elements. In previous works of the authors, experimental tests carried out on prototypes of this type of connection showed high strength and stiffness with respect to those of the connected elements, highlighting its potential for practical use. Later on, numerical models based on a typical case were developed, aiming at investigating the intensity and distribution pattern of stresses and strains. This paper is a follow-up of that previous research, and its main goal is the evaluation of two complementary reinforcement possibilities. Firstly, and as splitting in the bonding region, caused by tension perpendicular to the grain, is one possible but undesirable failure mode, the improvement of strength through the use of screws inserted perpendicularly or at an angle with the timber grain was investigated. The other proposed strengthening device consists of a short bonded rod across the timber-concrete interface and placed close to the middle depth of the cross section. This element is intended to reduce the shear stresses in the upper tensile reinforcement as, due to the interface gap caused by the tensile stresses, shear is fully supported by the compressed part of the interface and the upper reinforcement, reducing the strength of the latter available to withstand bending tensions. Plane stress numerical models were developed in a finite-element based structural analysis program. To account for the timber-to-rod interface debonding caused by tension perpendicular to the grain, linear models were iteratively considered where overstressed elements at the interface were successively removed until the tensile stress perpendicular to the grain was smaller than the strength. Finally, the various reinforced and unreinforced (reference) models were compared.

CODE 257**GRAPHENE OXIDE AS ADDITIVE FOR INCREASING THE STRENGTH AND DURABILITY PERFORMANCE OF EXISTING CONCRETE STRUCTURES****Longarini, Nicola¹; Cabras Luigi²**

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KEYWORDS: Graphene; Graphene-based nanosheets; Concrete Building Restoration.

ABSTRACT

Graphene and graphene-based nanosheets (GNS) have valid mechanical, thermal and electrical properties, enabling interesting applications for improving structural strength and durability. If combined with the Ordinary Portland Concrete (OPC), they can enhance its mechanical behaviour, an analogous improvement in terms of strength can also be seen in Ultra-High-Performance Concrete (UHPC). These features appear very useful in case of the restoration of existing concrete structures, thanks to the durability properties due to the GNS. Providing a wide state of the art about the use of GNS in concrete structures, this paper shows the strength improvements achievable in term of strength and durability. The benefits are finally discussed in relation to the restoration of existent concrete buildings.

CODE 260**USE OF REMOTELY PILOTED AIRCRAFT (DRONES) FOR THE INSPECTION OF ARCHITECTURAL HERITAGE AND ANCIENT STRUCTURES****Rodríguez Elizalde, Rubén¹**

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KEYWORDS: Drones; Heritage; Roman Bridge; Inspection; Heritage preservation.

ABSTRACT

The use of remotely piloted aircraft systems (RPAS), better known as drones, has spread with multiple and very diverse applications in recent years. It includes inspections of elements of the historical heritage, singular constructions and ancient or delicate structures. From various inspection heritage this article was born precisely: various several routine inspections and two significant monuments detailed inspection (Alcantara Roman Bridge and a section of Segovia Aqueduct), all of them with purely experimental purposes. With the completion of all of them and the information obtained, it will be possible to assess whether the aircraft can serve as a quality tool for carrying out the work that is currently being carried out with qualified personnel, the transportation and installation of bulky auxiliary means and a high economic and time investment, especially in the careful planning of the works. There is a very special impact on safety and risk reduction also: safety and risk reduction towards the monument to be inspected, and reduction of risks for the safety and health of the workers who currently perform such tasks.

CODE 269

USE OF BIOCEMENTATION FOR SEALING STONE JOINTS

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KEYWORDS: Biocementation; Joint sealing; Stone; Tensile strength; Ultrasonic pulse velocity.

ABSTRACT

Biocementation consists in using enzyme or non-pathogenic bacteria to produce calcium carbonate (biocement) and is being used to seal cracks in stone and concrete for retrofitting and consolidation works, as alternative to conventional solutions such as using polymeric mortar. The results of an experimental study performed to evaluate the efficiency of this green technique to seal joints in stone samples are presented in this paper. Joints with 1 mm width, having an artificial rough surface, were artificially created on basalt stone disks and treated by biocementation. Sealing was evaluated by measuring the flow of water through the joint. The adhesion was evaluated by tensile strength measurements in Brazilian splitting tests, in which the samples were split by the sealed joint. The joint surfaces separated after the splitting test were analysed by stereomicroscope images to check the presence and homogeneity of the precipitated biocement, and by digital analysis of photographs using Structure from Motion (SfM) photogrammetry. The profiles of the biocement cover allowed confirming the presence of some contact points between the two surfaces of the joint and the heterogeneity of the treatment, therefore explaining both lack of sealing and still some strength observed. Strong adhesion was achieved in spite of the heterogeneity, as failure occurred through the biocement. The tensile strength measured was between 25% and 50% of the value found for the intact rock. The results indicate strong adhesion between the stone and biocement. By comparing these results with those found in stone joints of the same material, with similar widths but with smooth and rough surfaces, it can be confirmed that biocementation appears to be adequate for sealing stone joints with identical properties to those investigated. The paper ends discussing the conditions for treatment application in real cases and how its efficiency can be improved.

CODE 277**APPLICATION OF NANOTECHNOLOGY TO OBTAIN SUSTAINABLE CEMENT-BASED MATERIALS WITH HIGH DURABILITY**

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KEYWORDS: Metakaolin; Nanomaterials; Slag; Sustainability.

ABSTRACT

In order to amortise the current high cost of civil engineering infrastructures, it is necessary to achieve a useful life of more than 100 years. This requires a significant increase in their durability in the face of aggressive agents. This requirement must be compatible with the reduction of the carbon footprint of the materials used. Both requirements call for the use of new functional materials that combine both objectives. For some years now, the use of nano-additives has been gaining ground in cement-based materials. Although it was initially speculated that their effect would be limited to a change in reaction kinetics determined by the increase in surface area, the latest studies show that the changes go as far as the structure of the silicates. Changing their mechanical behaviour and durability.

In this research, an experimental study of the properties of pastes and mortars with blast furnace slag (BFS), nano-silica (NS) and metakaolin (MK) has been carried out. The starting point is the dosage of cement pastes with EHA with an approximate substitution percentage of 75%; nanoaddition of NS and MK with a substitution percentage of 2% and 8% respectively, substitutions in weight of cement. The analyses were carried out by thermogravimetric (TGA), X-ray diffraction (XRD) and infrared (FTIR) techniques. The work presents the structural and microstructural characterisation of pastes with different compositions of slag, metakaolin and nano-silica.

The results obtained in the tests showed a significant increase in the microstructure and a modification of the portlandite with respect to the reference value, which allows obtaining sustainable functional materials.

CODE 306

POSSIBILITIES OF USING CALCIUM HYDROXIDE-BASED NANOMATERIALS IN THE CARE OF HISTORICAL SURFACES

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KEYWORDS: Plaster; Lime water; Lime nanosuspension; Consolidation; Strengthening.

ABSTRACT

Consolidation of historic lime plasters which have degraded binder component, disturbed structure, insufficient adhesion of individual layers to the masonry surface, with increased salt content in the pore system and surface crusts is a challenging task. At present, the consolidation of degraded lime plasters is carried out with consolidants which are applied in the form of solutions, in particular lime water, organosilicates or lime nanosuspensions, etc. The use of nanosuspensions (based primarily on calcium hydroxide), which today is one of the proven technologies used to strengthen degraded plasters, occurs, as with fresh lime plaster, carbonation, where calcium hydroxide reacts with atmospheric carbon dioxide to form calcium carbonate. Due to the deposition of calcium carbonate in the incoherent material, the bonds are reinforced and strengthened. Compared to lime water, the low number of impregnation cycles represents an indisputable advantage of consolidating plasters by lime nanosuspensions, where after several applications of the nanosuspension the disrupted material is strengthened.

The paper presents partial results of theoretical and experimental research focused on the possibilities of consolidation of historical surface layers (plasters) using lime water and newly developed lime nanosuspensions prepared by synthesis of $\text{Ca}(\text{OH})_2$, which were subsequently modified and enriched with other components.

CODE 351

GEOPOLYMER CEMENTITIOUS SOLUTIONS WITH INTEGRAL SUSTAINABILITY AND HIGH ADDED VALUE BASED ON CONSTRUCTION WASTES. KEOPS PROJECT: PRELIMINARY FINDINGS

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KEYWORDS: Construction sustainability; Circular economy; Geopolymer concretes.

ABSTRACT

Construction sector represents 40% of the total of the European Union energy consumption, 35% of its greenhouse gas emissions, one third of its water consumption and one third of the waste generated. Its main element, portland cement, is the second source of carbon dioxide emissions (4% - 7% of global CO₂ emissions) and, in addition, a large consumer of resources, using more than 400 million t per year of materials for its elaboration. In addition, the waste generated by this sector (named specifically construction and demolition waste (CDWs)) are more than 35 million t / year (28% of total wastes) in Spain.

Although studies on the development of sustainable cements, mortars and concretes are increasing day by day, proposed solutions advocating for both portland cement total replacement and sustainability are currently very scarce. Among these solutions are geopolymers, which use different aluminosilicate-based materials that, in conjunction with alkaline solutions, lead to sustainable cementitious materials. The project “KEOPS: Geopolymer cementitious solutions with integral sustainability and high added value based on construction wastes” promotes the development and optimization of new concretes, entirely sustainable and with high added value, based on the use of geopolymers, implementing circular economy strategies in construction industry through the reevaluation of high environmental impact wastes, namely construction and demolition waste (CDWs) and steel slags from electric arc furnaces in the steel industry.

This communication shows an overview of the main objectives and preliminary findings of Keops: new types of shot concretes (gunites); environmental remediation concretes; high chemical resistance concretes and prefabrication concretes with geopolymers in their dosages.

CODE 383

HEAT AND PRESSURE DEVELOPMENTS IN CHEMICAL DEMOLITION AGENTS

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KEYWORDS: Temperature; Heat of hydration; Expansive pressure; Thermal camera; Soundless chemical demolition agents.

ABSTRACT

Chemical-based demolition has been commercially available since the 1970s, although not widely applied, in part because of an absence of rigorous usage guidelines. However, both laboratory and field work has shown their viability as an effective alternative to traditional demolition methods, as it is noise and vibration free and, thus, attractive for use near historic structures and environmentally sensitive areas. While the available commercial products are known to generate heat and pressure, the formation and progression of those factors have not been well documented. Understanding of these factors can provide critical insights into developing procedures for the highly selective application of such materials both near and within historic structures. To this end, this paper presents a heretofore unpublished study on the development of heat and pressure in a metal pipe filled with a chemical demolition agent. The laboratory study employed a strain-gauged pipe filled with the material and a thermal camera that visually captured the highly irregular temperature development within the pipe. This paper presents the onset and evolution of heat within the pipe and the accompanying pressure development. Results showed the peak heat generation after 72 minutes. Rapid pressure gain began approximately 70 minutes before this when the sample reached 54.5 C.

CODE 6**ASSESSING THE THERMAL ENVIRONMENT OF SOUTH INDIAN HISTORIC
TEMPLE TOWNS BY USING CFD MODELLING****Kiruthiga, K.¹; Thirumaran, K.²**

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KEYWORDS: Traditional planning; Thermal Environment; Historic Temple town; CFD.

ABSTRACT

Historic temple towns of South India are unique and adapted to the local climate by their urban planning and spatial organizations. The traditional planning concepts of historic temple towns are rich and precious which should be extensively investigated. In this study, the historic temple town of Kumbakonam will be presented in terms of its urban planning forms and discussed through Computational Fluid Dynamics (CFD). The ambient wind environment of Kumbakonam has been quantitatively investigated by adopting CFD techniques. The settlement interaction and ambient environment were assessed. The traditional planning concepts of historic towns were outlined to design a sustainable module of human settlement that adapting the changing urban climate.

CODE 19**EXPERIMENTAL STUDY OF THE THERMAL AND MECHANICAL
PROPERTIES OF ECO-FRIENDLY CEMENT MORTAR INCORPORATING
RECYCLED PET AND PP**

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KEYWORDS: Waste plastic; Eco-friendly cement mortar; Energy efficiency; Sustainability; Thermo-Mechanical properties.

ABSTRACT

The low biodegradability of plastic and the presence of large quantities of plastic waste have a negative impact on the environment. The various forms of plastic consumed become waste and require large storage areas, as several tons of plastic waste cannot be fully recycled at one time. In the past, various studies have been conducted to identify environmentally friendly methods of plastic disposal. Recently, since cement mortar (CM) has a longer life span, different types of plastics have been incorporated into CM to reduce the direct contact of plastics with the environment. The objective of this paper is to evaluate the effect of using recycled polyethylene terephthalate (PET) and recycled polypropylene (PP) as a partial substitute for sand in CM to produce an eco-friendly cement mortar (E-FCM). A group of nine E-FCM blends were prepared with sand substitution levels of 0%, 5%PET, 10%PET, 15%PET, 20%PET, 5%PP, 10%PP, 15%PP et 20%PP. Appropriate tests were performed to evaluate the mechanical and thermal characteristics of the blends and compare them to the reference one. It was observed that there were improvements in thermal properties of E-FCM compared to the normal CM. The results are interesting and could encourage the development of this type of E-FCM in sustainable design and energy efficiency in the future.

CODE 38**PROPOSITION FOR HEALING MECHANICAL VENTILATION SYSTEMS
WITH RESONANT KEPPE MOTOR TECHNOLOGY: ANALYSIS IN A
BRAZILIAN PRIVATE SCHOOL****Koivukangas, Sari Hannele¹**

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KEYWORDS: Construction Pathology; Mechanical Ventilation; Fan; Keppe Motor.

ABSTRACT

This article is about mechanical ventilation systems in school buildings and their pathologies such as low energy efficiency and heat losses. As a healing process it proposes a qualitative and quantitative evaluation to replace the existing mechanical ventilation system for resonant Keppe Motor ventilation technology, applying the following parameters: existing mechanical ventilation, energy costs, ventilation quality, fan lifecycle, investment in technology, return on investment, reducing replacement and maintenance of fans, creating a more sustainable school environment. It presents a case study in a school in Brazil's subtropical region that aims at testing the efficiency and quality of conventional mechanical ventilation compared to a new resonant motor technology. As the healing of building pathologies involves costs, the investigation also verifies, the cost and savings of the two mechanical ventilation systems and their performance. The efficiency of mechanical ventilation in schools can be improved by at least 53% using a commercially available resonant motor technology.

CODE 52**BIOCLIMATIC STUDY OF THE ARCHITECTURE
IN THE EASTERN ALMERÍA****García-Ruiz, Luisa-María ^{1*}; García-Ruiz, Almudena ²; Sáez-Pérez, María-Paz ³**

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e-mail: mpsaez@ugr.es**KEYWORDS:** Bioclimatic design; Energetic simulation; Mediterranean architecture; Residential heritage; Vernacular architecture.**ABSTRACT**

Based on the fact that the vernacular architecture is a clear reference of the bioclimatic design, this research highlights the traditional housing in the East of Almería (Spain) in this point of view. Furthermore, the degradation of those buildings makes a rehabilitation necessary, in order to provide them a second life and avoid its ultimate disappearance. This is energetically viable due to its great original functioning. The main objectives are, firstly, defining the functional, shaping, constructive and material features, since they show that houses have a bioclimatic design. Secondly, contributing to the preservation of this Mediterranean vernacular architecture by highlighting its bioclimatic value. The used methodology studies the relationship of the building, the inhabitant and the near location, focusing in the climatic characteristics. It is known that the inner thermal behaviour is strongly determined by the climatic and geographic variables, so EnergyPlus software is used to study the energetic behaviour of the façades and roofs of twenty-eight traditional dwellings in the Eastern Almería, by thermodynamic simulations. In addition, this procedure can be transposable to similar constructions in other Mediterranean areas. Moreover, results show the great environmental quality of these buildings, thanks to their lighting and thermal loads, so a new use will cause low energetic requirements. The importance of the spread of said data assures the life increase of the traditional residential construction. Finally, the knowledge of the obtained information will allow to stablishing strategies in order to reduce the energetic demand of the analysed buildings.

CODE 54**PORTUGUESE PUBLIC SOCIAL HOUSING IN COVILHÃ, PORTUGAL. A CASE STUDY ON INDOOR THERMAL CONDITIONS DURING SUMMER SEASON****Brandão, Pedro¹; Lanzinha, João C. G.²**

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KEYWORDS: Summer season; Social housing; Energy poverty; Indoor thermal conditions.

ABSTRACT

Climate change predictions for Southern European Countries indicate severe adverse effects related to temperature increase and more frequent extreme events, which will result in comfort requirements in buildings to be more demanding. Some of the Portuguese public social housing building stock was constructed before the introduction of national thermal regulations; therefore they are limited to face this challenge. Thus, energy poverty conditioning in Portugal results in almost inexistent cooling habits recurring to active systems in social housing contexts. Therefore, this article provides an understanding of indoor thermal conditions on a social housing dwelling located in Covilhã during a summer season period. This dwelling was inhabited by an elderly resident, part of a risk group considering its exposure to improper indoor conditions. An experimental campaign was then performed regarding indoor temperature and humidity monitoring, while a questionnaire about the resident occupancy and cooling habits was answered. With both quantitative and qualitative data, indoor thermal assessment was applied for this period. Passive means alone were found to have no significant impact in indoor conditions improvement; therefore, improper thermal conditions were found to be extremely significant for the majority of the inhabited time period, which confirms that these buildings are much likely unprepared for the upcoming climate challenges.

CODE 67

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

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

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.

CODE 108**POLYFUNCTIONALITY IN UNIQUE ARCHITECTURES: KEY TO PERMANENCE
AND KEY TO SUSTAINABILITY****Agudo Martínez, Andrés^{1*}; Vázquez Sánchez, Gloria²; Lucas Ruiz, Rafael³**

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e-mail: rlucas@us.es**KEYWORDS:** Singular architectures; Sustainability; Multi-functionality; Multi-use of the building.**ABSTRACT**

We have been asking ourselves whether it is possible to establish management models that allow us to consider singular buildings as sustainable. We start from the assumption that the conception of a singular architecture implies facing an initial investment higher than those that would correspond to any other of an ordinary nature.

However, this type of architecture has been, is and is expected to continue to be an iconic heritage for society. Models have been developed based on real data from which it can be deduced that the higher overall cost can be compensated by skills based on the symbolic value of the building and its own marketing, with the commitment of social leaders, the appropriate dissemination and commercial exploitation of the building's uniqueness.

Our paper aims to contribute a new factor that we consider indispensable to mitigate the difference in costs between a unique building and another without this designation, so that it can achieve maximum sustainability throughout its useful life: the multi-functionality or multi-use of the building and the possibility of assuming changes of use over time.

CODE 114**SEISMIC AND ENERGY RETROFIT OF HISTORIC BUILDINGS:
A MODEL TO SUPPORT INTEGRATED DESIGN****Roncaccia, Elisa^{1*}; Losco, Giuseppe²**

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KEYWORDS: Integrated strategy; Retrofit; Energy improvement; Structural consolidation.

ABSTRACT

Over time, the issue of protecting the built heritage has deviated from the concept of passive conservation, understood as mere maintenance of what exists, moving instead to frame the need to update the urban fabric according to new, multiple, needs of use.

The theme of energy improvement has been applied to the existing built heritage because it's fundamental to confirm functionality and role within contemporary living; at the same time the seismic events that have occurred over time on the Italian territory, as well as the awareness of its intrinsic seismic hazard, outline the need to intervene in a preventive manner on buildings, through the execution of seismic improvement interventions. This is all the more true for historic buildings, built using construction techniques and materials free from adequate reference seismic laws.

Although the intervention policies for seismic improvement and energy adaptation have always shown a consolidated disjointed approach, the tax incentive strategies have gradually outlined the opportunity to act simultaneously.

The research therefore aims to combine structural and energy themes, proposing reflections, methodological approaches and transversal readings, useful to promote integrated retrofit strategies, in particular from the perspective of the protection of historic buildings, thus aiming at interventions that are calibrated and integrated with the identity of the historic towns.

The study outlines the state of the art of both seismic and energy improvement techniques applicable to historic buildings; it also reorganizes theoretical, economic, legislative, operational and fiscal information relating to the two themes.

The result of the research is a methodological proposal, with which to provide common guidelines and investigate possible interferences between the themes, highlighting the convenience of joint actions and promoting integrated retrofit strategies. The multidisciplinary theoretical and methodological substrate thus elaborated is then transformed into a digital tool, a web app that makes immediately available all the information and greatly simplifies the procedures.

CODE 116**ANALYSIS OF PASSIVE AIR-CONDITIONING SOLUTIONS IN THE
RENOVATION OF COURTYARDS IN A MEDITERRANEAN CLIMATE**

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KEYWORDS: Mediterranean courtyard; Refurbishment; Albedo; Vegetation; Urban heat island.

ABSTRACT

The phrase Urban Heat Island (UHI) is applied to a specific thermal phenomenon characterised by an increase in air temperature measured in the urban area compared to that of the surrounding rural environment. Some vernacular passive strategies, such as urban layout geometry and courtyard geometry, have proven to be useful in generating specific microclimates, especially in warm regions of the Earth. In the case of courtyards, they increase the porosity of cities, understood as voids in the built-up blocks that increase the shading planes and natural ventilation possibilities of buildings. Therefore, a study focused on these spaces, before the refurbishment of buildings with courtyards, would be beneficial both to reduce the effect of UHI by generating controlled microclimates and to improve the thermal performance of the building itself when it is subjected to a mixed climate regime.

In this work, several passive strategies capable of modifying the thermal effect inside the courtyard are analysed and quantified in real case studies. For this purpose, different buildings with courtyards inserted in the urban fabric of the city of Seville in southern Spain have been evaluated. The results show that the temperature in these spaces can vary considerably depending on the different construction resources used. The study analyses various strategies with high thermal performance and low cost, which are relatively easy to undertake in building renovation processes. It also proposes the quantification of these improvements as a method of valuation as passive air-conditioning resources, especially in hot environments where the need for thermal resilience in the coming decades will be more pressing.

CODE 120

BUILDING RETROFITTING IN VULNERABLE CONTEXTS USING END-OF-LIFE HOUSEHOLD MATERIALS AS SUSTAINABLE AND LOW-COST INSULATING SOLUTIONS: THERMAL AND ACOUSTIC ANALYSIS

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KEYWORDS: Urban Vulnerability; Circular Economy; Rehabilitation; Comfort; EoLHM.

ABSTRACT

Urban vulnerability is a common social phenomenon in many developed countries. In the orbit of urban vulnerability there are concepts such as exclusion, marginality and poverty that, although they are not synonymous, can reinforce each other. The city of Barcelona, like other cities in the world, suffers from strong vulnerabilities and internal inequalities as a result of differences in the social composition of a population through spatial distribution. El Raval is the neighborhood with the highest concentration of poverty in the entire urban area of Barcelona. El Raval is characterized by two population groups: the elderly and low-income immigrants, who often live in an environment of old and poor quality construction, in conditions of energy poverty and without access to minimum thermal and acoustic comfort, which resulting in additional social and health problems. This manuscript aims to move towards possible improvements in the thermal and acoustic comfort conditions of these people, providing low-cost, simple and fast construction solutions that also contribute to the circular economy by investigating the possibility of converting end-of-life household materials (EoLHM), such as clothing or packaging, into low-cost thermal and acoustic insulation materials for the improvement of thermal and acoustic comfort in buildings, especially for homes. vulnerable at risk of energy poverty. For this purpose, a review of the literature and an analysis of the acoustic and thermal behavior of different EoLHMs will be presented in order to identify the most suitable solution. From the acoustic point of view, the best compromise between acoustic absorption and transmission loss has been obtained for samples made of cardboard, but interesting results have also been obtained for samples made with two egg cups, especially in terms of transmission loss. Also, it has been shown that garments with higher density ensure better acoustic performance. From the thermal point of view, the installation of clothing and cardboard panels determines, respectively, a reduction in the periodic thermal transmittance and the thermal transmittance. However, due to their higher density, panels made from clothing are more effective. The most important result of this research is the understanding that the conversion of EoLHM into insulating materials is possible, and implies a direct reduction in waste production, with clear and evident environmental benefits and positive social implications.

CODE 153**INSTALLATION OF DIFFERENT PHOTOVOLTAIC SYSTEMS IN A BUILDING
FOR EDUCATIONAL USE****Zurro, Belén¹; González, Sara¹; González, José Manuel¹; Rodríguez, Ángel¹**

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KEYWORDS: Photovoltaics; Retrofitting; Renewable Energy; Ventilated facade; BRESAER.

ABSTRACT

Under the European research project BRESAER, during the spring of 2019, one of the pavilions of the Old Burgos Military Hospital was rehabilitated, with the improvement of the thermal envelope, the redesign of the ventilation, and the incorporation of an energy generation system by photovoltaic installation.

The intervention of the rehabilitation process as a unit was aimed at improving the energy efficiency of the building, reducing its demand, and introducing renewable energy sources.

The installation of three independent photovoltaic systems was designed. Two are located on the south façade, one of which is integrated into the ventilated façade itself, replacing the cladding layer, and the other superimposed on the outer layer of polymer concrete. The third system was placed on the south-facing roof.

This paper shows the installation process of the three PV projects, analyzing them separately and comparing the technical advantages of each one.

Having analyzed the systems separately, an energy study of the operating facility was also carried out using inverter monitoring. Obtaining in this way the real power produced by the panels.

CODE 154**CHECKING THE TECHNICAL SUITABILITY OF THE VENTILATED
FAÇADE SOLUTION****Zurro, Belén¹; González, Sara¹; González, José Manuel¹; Rodríguez, Ángel¹**

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e-mail: bzurro@ubu.es, web: <https://investigacion.ubu.es/investigadores>**KEYWORDS:** Ventilated façade; Energy Efficiency; Passivhaus; Wood; Natural stone.**ABSTRACT**

The European Union's requirements in terms of energy efficiency are increasingly demanding, which means that new construction solutions must be considered in the housing stock.

The techniques provided by ventilated façade systems, consisting of a supporting wall, a layer of insulation and a layer of cladding, are an excellent alternative for meeting these requirements and, at the same time, contribute to improving the aesthetics of buildings.

This study describes the analyses and tests necessary to check the technical suitability of a Ventilated Facade Construction System consisting of 15 mm and 20 mm thick natural stone slabs of limestone and/or sandstone, fixed by means of visible staples on the outer face of the enclosure, on waterproof particle wood panels.

The use of this type of solution, in which the metal substructure for the placement of the cladding layer is dispensed with, has important advantages: environmental protection, cost reduction, reduction of errors during execution, reduction of thermal bridges and, therefore, improvement of energy efficiency, etc.

In order to check the functionality of the designed Ventilated Facade Construction System, firstly, the correct functioning of the wooden boards as a support sheet will be checked, and the physico-chemical characteristics of the natural stone will be analysed. On the other hand, the complete construction model will be studied.

CODE 155**CATALOGING ROOFS FOR THE APPLICATION OF NBS
IN EDUCATIONAL BUILDINGS**

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KEYWORDS: Nature Based Solutions NBS; Greenroofs; Energy refurbishment; Geographical information system; Environmental quality.

ABSTRACT

Among the nature-based solutions (NBS), the green roof is a very interesting strategy for the renovation of educational buildings. On the one hand, it reduces overheating inside the building in the warm months, on the other hand, it reduces energy needs for air conditioning and mitigates the effect of climate change. In addition, it can help improve biodiversity and serve as a support for educational resources in schools.

The work presented shows the study of the roofs of school buildings in Badajoz, in order to know the possibilities of rehabilitation with nature-based solutions. For this purpose, a methodology based on geographic information systems is used, with georeferenced data from LIDAR, Cadastre, PNOA Orthophoto,... contrasting the indicators obtained with the detailed study of each roof.

The results obtained allow validating the methodology for this type of buildings and therefore being able to extrapolate the results. This study is part of the LIFE MBIG project, which analyses various Nature Based Solutions for the adaptation of buildings to Climate Change.

CODE 163

APPLICATION OF EE-HBIM METHODOLOGY TO THE ENERGY RETROFITTING OF A HERITAGE PUBLIC BUILDING IN VALENCIA

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KEYWORDS: Public heritage buildings; Energy retrofitting; HBIM (Historic Building Information Modelling); EE-HBIM (Energy Efficiency in Historic Building Information Modelling); Energy retrofitting; BIM to BPS interoperability.

ABSTRACT

As pointed out by the European Commission, roughly 75% of buildings in the EU are not energy efficient and, although 85-95% of them will still be in use in 2050, only 1% of them undergo energy-efficient renovation every year. As outlined in the European Green Deal, building energy renovation is key to achieving a climate-neutral Europe by 2050. In this respect, public buildings can lead the wave of renovation, serving as a role model and benchmark, and making the co-benefits of energy renovation immediately visible to the public.

However, there are a number of barriers to the energy renovation of public buildings, which are even more limiting in the case of heritage buildings. This paper aims to present a methodology based on the specific application of BIM for cultural heritage (HBIM, Historic Building Information Modelling), developed with the goal of facilitating strategies to the local public administration for the deep renovation of heritage buildings. To the geometric dimension of the HBIM model (3D), dimensions of time, costs, and environmental/energy behaviour of the building (4D, 5D, 6D) are added. The resulting enriched model (EE-HBIM, Energy Efficiency Heritage Building Information Model) is the basis for the development of three energy renovation scenarios in the short, medium, and long term. Specifically, this paper presents the results obtained so far by applying this methodology in a heritage building located in València (Palacio de Calatayud). Interoperability between modelling and energy simulation software is also addressed in the methodology, which is being developed in the framework of the BEEP project (BIM for Energy Efficiency in the Public Sector) and tested in other heritage buildings located in six more countries of the Mediterranean basin. The BEEP project, funded by the EU under the ENI CBC Mediterranean Sea Basin Programme, is led by the Istituto di Scienze del Patrimonio Culturale ISPC-CNR.

CODE 171

SIMULATION ANALYSIS AND THE ROLE OF OCCUPANCY MEASUREMENTS ADDRESSING THE ENERGY PERFORMANCE GAP. STUDY OF AN OFFICE BUILDING IN ALMERÍA

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KEYWORDS: Building energy performance; Occupancy patterns; On-board monitoring; Building energy simulation.

ABSTRACT

Building performance simulations are widely used for the estimation and optimization of building performance. The development of design tools in the building sector commonly used in regulatory procedures for energy labelling and certification are based on the objectives expressed by the various directives passed by the European Union starting in 2018 to increase the energy efficiency of existing buildings and new. The convergence of this necessitates to improve the reliability of energy simulation results to reduce the performance gap between the design and operation of buildings. However, the assumptions made in the modelling of the building, the deviations introduced in the implementation with respect to the design specifications, as well as the simplifications implicit in these simulation programmes, give rise to discrepancies that can be relevant between the real behaviour of the building and the one predicted according to these simulations. An important cause of discrepancies in the building energy simulation and energy management in buildings, which is also the main objective of this work, is the occupant behaviour modelling. This important input is typically modelled by default occupant schedules from the standards or choices made by modeller. To further understand the way occupants are incorporated into building design and operation practice throughout the building life-cycle, an office building located at CIEMAT's Plataforma Solar de Almería (PSA) is considered. Its energy performance is evaluated from dynamic simulations considering different occupancy profiles. A comparison is made with the results obtained considering the occupancy profiles established by the Spanish energy certification regulations for this type of buildings, and the occupancy profiles experimentally determined from the metabolic CO₂ and from the electricity consumption in the offices. The study focuses on the annual thermal loads evaluation achieved by two representative offices in this building, when its occupancy patterns change.

CODE 177

HYBRID SOLUTION FOR ELECTRIC AND COLD-WATER PRODUCTION WITH A DUAL DAY-NIGHT BEHAVIOR AS A NATURAL AIR CONDITIONING TECHNIQUE

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KEYWORDS: Energy saving; Photovoltaic/thermal system; Natural technique; Heat sinks; Falling-film.

ABSTRACT

In this work, an innovative natural air conditioning solution is studied that combines electricity and cold-water production through a dual day-night technique on photovoltaic panels. The proposed innovative natural technique uses water as a natural element for heat dissipation. The cooling of the water is obtained through a technique known as "falling film", which consists of throwing the water on the photovoltaic panels during the night, taking advantage of the potential of the sky as a radiant heat sink. The water-cooled at night is accumulated in deposits and used in the conditioning system of the house. Likewise, the electricity produced in the day mode can be used by the home, stored or even exported. The system has been evaluated and characterized using experimental data. A monitored experimental prototype has been carried out to model the proposed technique. The inclination favours the maximum performance of the descending water film, water flow, path of the water film, and the nozzle and its optimal position for the correct development of the descending water film have also been studied. This characterization has allowed the evaluation of the energy impact of the proposed solution as an alternative for rehabilitation in residential buildings. The results prove that it is possible to achieve savings of more than 55% in the cooling demand through the descending blade and an electrical production equivalent to the home's energy consumption.

CODE 180**INNOVATIVE INTEGRATION OF ACTIVE ROOF ON 140 SOCIAL HOUSING**

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KEYWORDS: Integral rehabilitation; Innovative solutions; Natural sinks; Active roof.

ABSTRACT

The current climate situation makes it necessary to act on the building sector to improve energy efficiency by mitigating the effects of climate change. The energy-poor social housing districts in southern Spain present a serious problem of overheating in cooling conditions, causing residents to find themselves outside the comfort limits for a high number of hours. In these cases, conventional measures to improve the performance of the building envelope are not enough. This paper presents the action carried out on a district of social housing in southern Spain, Jaén. To improve the conditions of thermal discomfort, rehabilitation improvement measures are proposed based on the improvement of the envelope's behavior. In addition, due to the prevailing cooling climate, an innovative ventilated roof solution is designed and integrated as a passive cooling technique that enables the use of environmental heat sinks such as night ventilation and evaporative cooling. It is a real case integrated in more than 2500 m² of roof, acting on a district of 140 social housing blocks. The implementation of this comprehensive rehabilitation has allowed to achieve a significant reduction in thermal discomfort in the district, achieving a reduction of up to 80% in the cooling regime thanks to the design and integration of the roofing solution.

CODE 191

INTEGRATED REDEVELOPMENT OF INDUSTRIAL BUILDINGS: A CASE STUDY IN CENTRAL ITALY

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KEYWORDS: Energy saving; Energy redevelopment; Integrated retrofitting; Industrial buildings.

ABSTRACT

According to the Global Status Report REN21 the buildings are responsible of around one third of global final energy consumption and 28% of greenhouse emissions. In the context of the European Sustainable Development Goals and the aim of the European Union at obtaining a free-carbon economy within 2050, it is necessary reducing primary energy demand and greenhouse gas emissions during operational phase of the industrial buildings, whose impact is underestimated.

The paper concerns with the Tuscany's context, characterised by an industrial buildings stock mainly built before the '90s with reinforced concrete prefabrication systems. All these buildings share similar architectural, structural and technological characteristics as well as common issues: structural and energy due to both external envelope thermal insulation and systems for energy supply. Moreover, the presence of asbestos in roofing elements requires urgent interventions. As clearly emerging, the integrated redevelopment of industrial heritage is an urgent topic of interest.

A preliminary assessment of construction technologies, recurring characteristics and typological factors was carried out in two different geographical areas in Tuscany, leading to several statistical data used to define recurrent industrial building types. Starting from the energy requalification of a building representative of the most widespread category, the research aims at defining a methodology for multidisciplinary retrofitting to be applied also to other building types with the same intended use. The approach is based on reducing both primary energy demand and CO₂ emissions. This can be achieved with energy efficiency measures addressing envelope components and more efficient systems for both heating, cooling and industrial processes using renewables for energy supply. Sensible energy savings and improvements in internal conditions can be achieved. As regards energy production, the only introduction of the photovoltaic system on the roof is not enough to satisfy the loads required by the manufacturing process on colder months.

CODE 212

ENERGY EFFICIENCY AND PRESERVATION OF DIFFUSE HISTORIC BUILDINGS: OPPORTUNITIES AND OPEN QUESTIONS

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KEYWORDS: Sustainability; Energy efficiency; Historic residential buildings; Cultural heritage; Passive green building.

ABSTRACT

The aim is to address the issue of architectural heritage belonging to the diffuse residential buildings, most of which are privately owned and used as residences, to the possibility of being subjected to energy retrofitting, a highly topical issue, while at the same time maintaining their historic features and aesthetic prerogatives.

If the historical-constructive characteristics of the constructions of the residential buildings are taken into account, it emerges that they are the result of a centuries-old relationship between the environment in which they were conceived and been renovated over centuries and the resources offered by the territory itself. For essentially utilitarian reasons, they have defined peculiarities that do nothing more than support and enhance the place where they were built. The extensive use of wood, the oversized structures, the orientation of the buildings and their closeness, when they are located in urban centres, give widespread historic buildings specific features similar to those required today for the proper management of buildings from an energy point of view.

The energy retrofitting projects should therefore be mainly linked to the air conditioning systems, which, with greater efficiency and less invasiveness, can increase the thermal comfort inside the individual building units, which in principle could be exempt from interventions that involve invasiveness in terms, above all, of aesthetics. In this regard, some examples of energy retrofit on historical residential buildings halfway between the farmhouse and the Lombardy courtyard will be analysed. At this juncture, the diagnostic analyses, mainly non-destructive and usually used in the field of restoration, can provide a valid and fundamental contribution both for the identification of thermal bridges in buildings, and to provide data for an effective dimensioning of the characteristics of the system and its placement within the building units, without any disruptions and maximising the qualities linked to their conformation and structure. In conclusion, a discussion is made that attempts to combine respect for the historical characteristics of a building with energy efficiency work, trying to make it more durable and more environmentally sustainable, but also trying to meet the legitimate aspirations of the property.

CODE 323**ENERGY EFFICIENCY AND COST OF ENERGY (POSSIBLE SCENARIOS)**

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KEYWORDS: Electricity bill; Cost of energy; Profitability; Optimal point; Electric self-consumption.

ABSTRACT

There are several factors that can influence consumer interest in energy efficiency actions in buildings to reduce the amounts associated with electricity bills.

Knowledge of the items on the electricity bill, the established regulations and current energy trends help to establish a future forecast of the scope of the cost of energy, especially electricity, for the user.

In this way, various shifts in the economic analysis curves that provide information on the profitability of the investments and the possible scenarios that could arise can be considered.

CODE 346**THE IMPACT OF SEISMIC RETROFIT ON THE THERMAL PERFORMANCE
OF TRADITIONAL MASONRY WALLS**

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KEYWORDS: Energy performance; Thermal transmittance; Seismic retrofit; THERM.

ABSTRACT

It is well known that the retrofitting of existing structures is an increasingly leading branch in the construction sector. It is also widely acknowledged that, because they were constructed in an era in which energy efficiency and seismic resistance requirements were not a critical part of the design, a very significant part of existing building stock presents an inadequate performance in both energetic and structural terms. However, and despite this issue is already assumed by government and academic institutions as a major priority, there is still an evident lack of knowledge concerning combining these two topics in a comprehensive and unified manner.

In this research, an extensive set of thermal simulations were carried out to evaluate the impact of different seismic retrofit measures in the thermal transmittance of a traditional masonry wall. To that end, two-dimensional heat transfer models were created in THERM software, and the U-value of the walls were computed, both before and after the seismic retrofit.

The results revealed that the thermal heterogeneities resultant from the seismic retrofit can provoke an increase in the U-value of the wall by up to 30%. On the other hand, introducing an additional layer of a thermal rendering minimizes the problem.

CODE 377**NEW MATERIALS IN THE RESIDENTIAL THERMAL CONDITIONING.
APPLICATION IN A HOUSE IN THE CITY OF LOJA, ECUADOR**

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KEYWORDS: Geopolymerized brick; Thermal transmittance; Energy simulation; Embodied energy.

ABSTRACT

The objective of this work is to optimize the thermal conditioning of residential buildings, whether new housing or rehabilitation of its envelope; The study focuses on the thermal performance of new materials such as geopolymerized brick versus solid handcrafted brick or fired clay, correlating with social and environmental well-being.

For this purpose, a conventional technology house has been selected, built in reinforced concrete and solid artisanal brick masonry, where the thermal behavior is analyzed based on the thermal transmittance value of the components that make up its envelope. The BES (Building Energy Simulation) has been carried out through the use of specialized software, comparing seven envelope systems configured with solid artisanal brick, and/or geopolymerized brick, in relation to the base case. The result of this study suggests the use of a construction package that includes geopolymerized brick; due to the fact that it is a sustainable material with low consumption of incorporated energy and low carbon emission in its production process, which meets the requirements of thermal comfort, clean technologies and sustainability by using residues of fired brick residues for its elaboration.

CODE 382**PRELIMINARY THERMAL ANALYSIS OF A CONTAINER HOUSE IN THE
NORTHERN REGION OF PORTUGAL**

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KEYWORDS: Tourist facility; Container; Thermal comfort; Sustainability; Rural tourism.

ABSTRACT

There is currently an increase in the number of properties dedicated to rural tourism in Portugal, which are generally located in environments with low population density and old infrastructures. In this context, this work presents a type of innovative construction with sustainable characteristics, a house built from a reused container in the interior of the northern region of Portugal, in a place that is the route of agrotourism. However, given the thermal problem that this type of construction must overcome due to the high thermal conductivity of steel, added to the high solar incidence of the region in the summer tourist period, added the desire not to intend to change the external appearance and the limitations of the interior measurements of the container, it becomes a complex task to try to achieve thermal comfort. There are still few scientific works to study the thermal behaviour of this type of building, so in this preliminary work, a series of exterior and interior temperature measurements were carried out to evaluate the influence of shading elements on the thermal comfort in the container. This solution proved to be effective, reducing the interior surface temperature of the container walls by around 40%.

CODE 396

USING DIGITAL MODELS OF BUILT ENVIRONMENT ARCHETYPES TO ANALYZE AND COMMUNICATE CLIMATE RELATED RISK OUTDOORS

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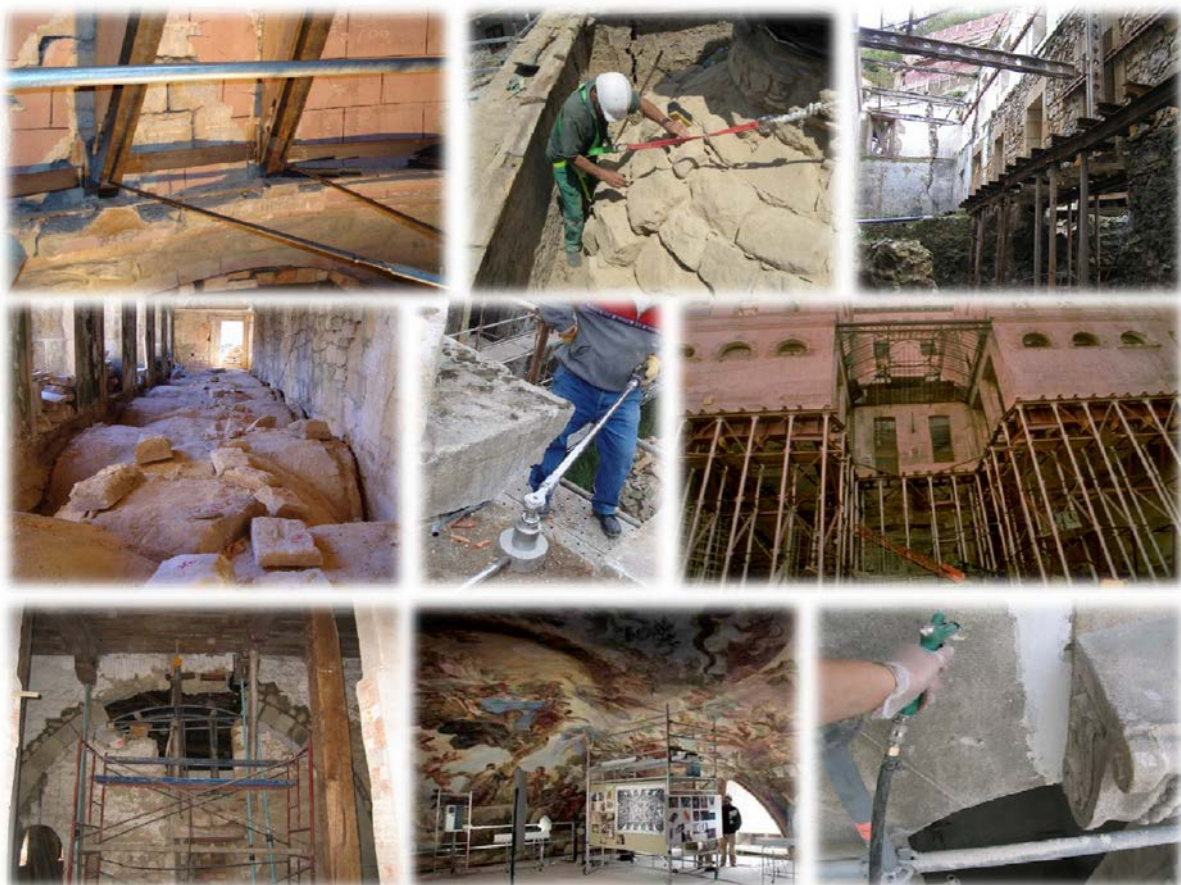
KEYWORDS: Built Environment; Risk assessment; Heat stress; Air pollution; Digital model.

ABSTRACT

Slow Onset disasters on infrastructure and inhabitants are more frequent in the urban environment worldwide. In specific, urban heat island and urban pollution types, which are due to changes in the patterns of human settlement. Such settlements (cities) are characterized by high energy use, intense traffic, and the pressure on natural resources. However, the urban environment is composed of several geometries, materials, and combinations of such that would require extensive analysis to prepare solutions to mitigate Slow Onset disaster risks for every singularity. Utilizing constructed archetypes of a contextualized urban environment and running computer-aided simulations on microclimate dynamism (heat and air pollutants), simplifies the analysis for tackling slow onset disasters risk on a larger scale. In particular, enabling robust studies on built heritage which are less likely to embrace intrusive mitigation works. Critical areas and climates were identified for representative Italian outdoor piazzas using 3D digital models, calculating for a significant period the distribution and intensity of Universal Thermal Comfort Index and the Air Quality Index with Ladybug Tools and ENVI-met. Air pollution levels were found low on summer seasons, reducing the possibility of suffering in parallel from air pollution distress and heat stress. In addition, spaces under intense direct solar radiation on temperate climates can result on higher heat stress condition than those found on a warm climate. The wind velocity distribution plays a major role on abating both increasing temperatures and air pollution effect on dense built environment inhabitants.

3.- BUILDING INTERVENTION

- 3.1.- INTERVENTION PLANS.
- 3.2.- REHABILITATION AND DURABILITY.
- 3.3.- REINFORCEMENT TECHNOLOGIES.
- 3.4.- RESTORATION OF ARTWORKS.
- 3.5.- CONSERVATION OF INDUSTRIAL HERITAGE.
- 3.6.- EXAMPLES OF INTERVENTION.



CODE 186**SPECIAL PROTECTION PLANS OF HISTORICAL SETS IN SEISMIC AREAS:
THE PEPRICH OF LORCA****García Martínez, María del Sagrado Corazón¹; Martínez Ríos, Carmen²**

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e-mail: mcarmen.martinez5@carm.es**KEYWORDS:** Special Plan; Historical sets; Seismic area; Lorca; Cultural heritage.**ABSTRACT**

On May 11, 2011, an earthquake of Mw 5.2 that occurred at 6:47 p.m. local time affected the city of Lorca, causing severe damage to the cultural assets of its historic center, declared a Site of Cultural Interest with the category of Historic Site. It was a seismic movement preceded by another of magnitude Mw 4.6, at 17:05 local time, considered as a precursor event.

The emergency actions in movable and immovable property depended on their cataloging, prioritizing the real estate declared Assets of Cultural Interest, to continue with those cataloged with grade 1 and 2, in accordance with the Special Protection Plan of the Historic Complex of Lorca (PEPRI) approved in 2001.

For the recovery of the cultural heritage of Lorca after the earthquake, the Ministry of Culture promoted the development of the Master Plan for the Recovery of the Cultural Heritage of Lorca as a coordination tool between administrations, approved by the Council of Ministers on October 28, 2011. In Within the framework of the Master Plan, one of the Auxiliary Programs developed has consisted of the Review and Expansion of the PEPRI (PEPRICH).

This document is in the initial approval phase and is being drafted based on the conclusions of different studies that have been prepared on the seismic risk in the city of Lorca, among which are those of the Seismic Microzonation of the urban area carried out by the Polytechnic University of Cartagena, with the aim of characterizing the existing potential seismic risk on an adequate scale, developing regulations for protection and urban planning that reduce the negative impact of the risk and increase the required earthquake resistance of the buildings that make up the cultural heritage in Lorca.

The innovation of PEPRICH with respect to the cultural protection regulations related to seismic risk is analyzed, and the adaptation to the situation of the historic center of Lorca in the Falla de Alhama (FAM), compared with other similar Special Plans that guarantee adequate management due to seismic risk in historical sets.

CODE 214

DIGITAL SURVEY FOR BUILT HERITAGE PRESERVATION. AN ADAPTIVE REUSE PROPOSAL OF THE COMPLEX OF SANTA MARIA NASCENTE

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KEYWORDS: Chapel of Santissima Trinità; Built Heritage; Preservation; Digital Survey; Adaptive Reuse

ABSTRACT

This paper focuses on the analysis of the historical and religious complex of Santa Maria Nascente, located on the top of Pragatto hill, a natural and valuable environment in the province of Bologna, Italy; In particular, in-depth analysis and intervention strategy have been performed specifically on the Chapel of Santissima Trinità, as a prominent part of this religious complex. Currently, the building is in a state of abandonment and decay, as often happens for the deconsecrated minor ecclesiastical heritage, consisting of small churches, chapels, and convents. The reuse of this heritage becomes increasingly urgent to avoid the triggering of structural and architectural damages due to extended disuse periods. Consequently, the first purpose of the proposed intervention is the search for an appropriate use, different from the religious one, which could give new attractiveness to the complex, yet maintaining its cultural and social aims while enhancing its natural environment.

The digital survey carried out with unmanned aerial vehicle (UAV) photogrammetry or terrestrial laser scanning (TLS) is today an indispensable tool for cultural heritage preservation projects, where a high level of accuracy is required for the analyses that follow the historical research. Indeed, UAV photogrammetry or terrestrial laser scanning can help in the study of the construction characteristics, materials degradation and cracking framework to define how to intervene. The present case study considers the benefits that an in-depth survey gives in terms of the accuracy of the intervention proposal, whose result is a project at different levels, from a wider territorial one to a detailed seismic improvement.

CODE 360**CHALLENGES OF THE PRESERVATION OF HERITAGE BUILT IN STONE AND ARMED CONCRETE ON THE ISLAND OF MOZAMBIQUE****Alcolete, Isekiel^{1*}; Silva, J. Mendes²; Lage, Luís³; Mouraz, Catarina⁴**

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KEYWORDS: Mozambican Island; Current Built Heritage; Intervention Strategies; Constructive characterization.

ABSTRACT

The Mozambican Island, in the province of Nampula, has been enrolled in the UNESCO World Heritage List since 1991 through the IV and VI criteria, and is particularly relevant to the approach of this work: "representing an exceptional example of a type of construction or Architectural or technological or landscape set illustrating one or several significant periods of human history".

The island is a testimony of many centuries of history as it was initially occupied by the Bantu people from the third century. Between the centuries IV and X, Mozambican coast, center and North, they were part of a network of Chinese, Persian, Arabic, Hindus (from Guzerate), Moslim Indians and Portuguese, the latter from the end of the XV century. At each time, they left marks built with their own identities: the Chapel of Our Lady of Baluarte, in the XIV century, the Fortress of St. Sebastião, the Stone Town, in the north area, and the Macuti Town, in the south area. Later, in the middle of the XX century, mixed buildings of stone and armed concrete came up with several functions, both institutional and more informal.

This set is the one important to recover, preserve and value, reconciling your identity with your adaptation to new security and unworthy comfort requirements.

The attention is called, in general, on the vernacular construction in the Macuti Town, made of mangal rod, stone, land and palm leaf, threatened by a process of dwelling requiring study and reflection. However, the stone Town and the emblematic constructions of the beginnings of the armed concrete require equal attention, being mainly to them that this article is dedicated.

First, a summary characterization of these constructions is made, with identification of the most representative types and functions. The materials and technologies of construction and the state of conservation are described, identifying the main phenomena of degradation and, exploratory manner, future intervention strategies, in a perspective to promote and reconcile identity preservation, sustainability environmental and functional adequacy to current requirements for safety, comfort and health.

CODE 104**HOW A REFURBISHMENT CAN BLATANTLY MISS ITS GOALS:
THE PALAZZO STABILE IN POLLA (SALERNO, ITALY)****Marino, Francesco Paolo R.^{1*}; Lembo, Filiberto¹; Bruno, Pierluigi¹**

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e-mail: francesco.marino@unibas.it**KEYWORDS:** Anti-seismic upgrade of masonry buildings; Energy efficiency upgrade; nZEB; Decentralized VMC; Solar tubes.**ABSTRACT**

The rapid evolution of performance regulation, particularly in the structural and energy field, has made evident design errors that otherwise would not have been highlighted. In this way, many refurbishment interventions, carried out a few years ago, must be declared obsolete and worthy of substantial retrofits. It is the case of the Palazzo Stabile in Polla, rebuilt from scratch after the disastrous earthquake of 1857, and purchased in 1995 by the Municipal Administration which in the following years, with an intervention that ended in 2001, completely refurbished it, destining it to host seven social housing units. The building was thus subject to radical interventions of sub-foundation, reinforcement of the walls, replacement of the wooden suspended floors with reinforced concrete floors and wooden roofs with trusses and steel floors, reinforced concrete architraves on the openings, sanitary and thermal systems, floorings, plasters and finishes. Twenty years after his complete refurbishment, the building not only shows itself to be affected by important humidity pathologies but, on a more in-depth analysis, it turns out to be unsafe in terms of earthquake resistance and seriously inefficient from the point of view of fundamental requirements, there those relating to energy consumption, ventilation, acoustic insulation between and inside the apartments and natural lighting. Considering that the case is paradigmatic of the condition of many other buildings that have been the subject of interventions, especially after the seismic events that have affected many areas of Italy in the last forty years, the contribution illustrates the research carried out on the building, showing the reference methodologies relating to each step of the analysis and the results of their application. It starts from the description of the works carried out on the building; discusses their compliance with the mandatory standards at the time of implementation and with those in force today, the current state of the building and its pathologies. It proposes the necessary interventions to make the building safe and efficient, respecting its historical and architectural characteristics, with a view to sustainability.

CODE 137**CONCRETE CRACK REPAIR WITH EXPANSIVE GROUTS: CHLORIDE
PENETRATION RESISTANCE****Pedrosa, Filipe¹; García Calvo, José Luis²; Carballosa, Pedro³; Revuelta, David⁴**

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KEYWORDS: Durability; Expansive concrete; Repair; Corrosion; Chloride Penetration.

ABSTRACT

The present study evaluated the chloride penetration resistance of concrete specimens repaired with different expansive grouts. Segments of a precast reinforced concrete beam were intentionally damaged with a disc cutter on their surface which was then repaired with grouts. Four mixes of grout were tested. Three of the mixes contained different inorganic expansive agents, one CaO-based (G), and the other two ettringite-based (K and NK). The fourth mix was an ordinary portland cement grout. The repaired beam segments were then submitted to a chloride penetration test by means of an accelerated ponding method while monitoring the electrical potential of the steel reinforcement. After the test, concrete cores were extracted and chloride penetration depth profiles obtained for each specimen. The study showed that the reinforced concrete beam segment repaired with the expansive grout K, when compared to the ordinary grout, presented an inferior chloride penetration resistance. On the contrary, expansive grouts NK and G behaved adequately.

CODE 143**EFFECTS OF THE APPLICATION OF ORGANIC PLASTERS WITH ADDITIONS OF BEESWAX ON THE DURABLE CHARACTERISTICS OF EARTH-BASED MORTARS IN RURAL ARCHITECTURE****Encalada, Luz¹; Balcázar, Cristian²; Aguirre-Maldonado, Eduardo³**

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KEYWORDS: Earth mortar; Plaster; Beeswax; Mortar adhesion.

ABSTRACT

In traditional rural construction, the earth as an abundant and sustainable material has established itself as a reliable and environmentally friendly option, however, the main materials in contact with atmospheric agents such as coatings and plasters, which play a decisive role in the durability of the structural earthen wall, adherence and porosity of the mortars are directly related to reducing the service time of the structure by exposing it directly. Synthetic stabilizers offer good properties to increase adherence and waterproof mortars, although, they are not accessible materials in rural environments, moreover their degradation processes can become very prolonged and environmentally unfriendly. In this search for organic materials, the use of cane bagasse fibers, organic oils and beeswax is proposed as material to stabilize wall coverings, in addition to its possibility of developing in rural environments as a by-product, it could be used for soil and have the capacity to biodegrade at the end of its useful life. Therefore, the present research studies how to improve the durability characteristics of raw earth mortars by increasing their adherence and better protecting the surface through a linseed oil plaster and beeswax polishing. Series of test tubes are designed with traditional earthen mortars, earthen mortars reinforced with cane fibers and earthen mortars reinforced with cane fibers and plaster composed of earth and beeswax. The tests on the direct adhesion of these mortars and adhesion after wetting and drying cycles showed an improvement of qualities in the samples that use beeswax, corresponding to the results of low water absorption. Finally it was evaluated if the improved mortars decrease the thermal qualities of the coating necessary for the thermal inertia function of the wall, verifying that they do not interfere with these properties. To conclude, the results show that the inclusion of beeswax has an important role in the performance of the plaster.

CODE 189**DIAGONAL COMPRESSION TESTING OF TUFF MASONRY PANELS
STRENGTHENED WITH INORGANIC-BASED SYSTEM: AN EXPERIMENTAL
INVESTIGATION****Verre, Salvatore¹; Cascardi, Alessio²; Gallo, Fiorella³**1: Department of Civil Engineering
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e-mail: ing.fiorellagallo@gmail.com**KEYWORDS:** Heritage; Retrofitting FRCM/SRG system; Shear Testing.**ABSTRACT**

A significant portion of the structures around the world is made of clay- and tuff-based masonry. These structures are very vulnerable against earthquakes, so their seismic performances need to be improved. In the last two decades, the Fabric Reinforced Cementitious Matrix (FRCM) system was largely used for strengthening of historical masonry structures in alternative for the fiber-reinforced polymer (FRP). In the FRCM-category there is now a composite that includes steel fabric with within an inorganic matrix, namely the Steel Reinforced Grout (SRG). The herein reported experimental campaign was focused on a set of seven small square masonry walls (410x410mm and a thickness of 130 mm) with SRG-retrofitting, while an unreinforced masonry (SC) wall was tested as a control specimen, all the specimens were tested under diagonal compression load. The investigated parameters were the type of reinforcement (FRCM and SRG) and the number of fabric layers (from 1 to 3 layers).

CODE 206**NEW GENERATION ETICS COATINGS: AN INNOVATIVE AND HIGH-PERFORMANCE CASE STUDY****Curado, António^{1,2*}; Figueiras, Ricardo³; Gonçalves, Hélder³; Sambento, Filipe³**

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KEYWORDS: Building Rehabilitation; ETICS; Functional Performance; Cool Pigments; Durability.

ABSTRACT

ETICS (External Thermal Insulation Composite System) system must assure facades waterproofing, aesthetic improvement, and increased thermal resistance to varying weather conditions, including wind, rain, moss, and dirt, fire protection reinforcement, as well as preventing the proliferation of biological agents. The in-situ performance of the system relies heavily on the characteristics of the finish coating, which must provide higher cracking resistance, stronger waterproofing capacity, and permeability to water vapor, and also confer aesthetic functions such as texture and color. Most recently, with the emergence of new generation organic coatings, based on modified acrylic resins, specific additives, and cool pigments, called reflective pigments, the pathology related to color loss and cracking, as a result of the high surface temperature, has been considerably mitigated, improving the color stability of the coating and, consequently, the waterproofing.

The façade cladding of a large Shopping Centre in the North of Portugal was recently retrofitted by applying an ETICS dark-colored coating based on modified acrylic resins, specific additives, and cool pigments, and subjected to an experimental study. The new ETICS system allowed reducing original major pathologies like the coating aging, color loss, biological colonization, and system cracking, with a reinforcement of thermal comfort and fire protection. Additionally, it should be noted that the cost of application was reduced when compared to the conventional solution. After more than one year of use, the façade shows no pathology evidence.

CODE 232**REINFORCEMENT TECHNIQUES FOR REINFORCED
CONCRETE STRUCTURES****Guimarães, Marcos B.¹; Prola, Luis C.²; Rodrigues, Paulo C.³**

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KEYWORDS: Strengthening; Reinforced concrete; Design.

ABSTRACT

The strengthening of reinforced concrete structures has shown relevant in the civil construction context over the years. The need to reinforce a structure manifests itself when it is necessary to change the structural conditions defined in the design. The main reasons are (i) failure to comply with a limit state, (ii) premature degradation of materials and (iii) errors in both the design and in the execution of projects. The present work uses methods capable of increasing the resistance capacity of reinforced concrete structures to solve the problem without demolishing. The main objective is to apply the different techniques used in the reinforcement of structures to assess the safety and design conditions. To design the strengthening of reinforced concrete beams and columns, a calculation routine was developed based on the Brazilian and European standards for the design of reinforced concrete structures, (ABNT NBR 6118/2014 and on the Eurocode). It should be noted that both have similar specifications and the resistance found were close for each type of technique. In addition, it is evident that the methods provide an increase in the resistance of the structures, which can be observed by the significant increase in the resistant efforts when compared to the initially determined by design calculations.

CODE 295**INFLUENCE OF THE POLARIZATION RESISTANCE MEASUREMENT
PROCEDURE WHEN MADE POTENTIODYNAMIC ON THE EVALUATION OF
THE POWER OF CORROSION INHIBITORS****Argiz, Cristina^{1*}; de la Fuente, Diego²; Moragues, Amparo³; Andrade, Carmen⁴**

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e-mail: candrade@cimne.upc.edu, web: <http://www.upm.es>**KEYWORDS:** Corrosion inhibitors; Linear polarization resistance; Silane inhibitors; Aminoalcohol inhibitors.**ABSTRACT**

Polarization resistance is a common method to determine the corrosion rate in cement mortar or concrete. When the mortar is carbonated or contain chlorides, the steel corrodes and the corrosion rate exhibit values above $0.1 \mu\text{A}/\text{cm}^2$, while if corrosion inhibitors are present the corrosion rate shows values below that threshold. When measuring the polarization resistance, although it is assumed that the slope of the E/I curve is linear close to the initial corrosion potential, this is not always the case when the method of determination is potentiodynamic applying a previous cathodic step of -20mV to plot the E/I curve into the anodic direction. Thus, notable differences are observed depending on whether the slope is fitted when reaching the previous corrosion potential or when a E/I trend is noticed to be linear. In the case of the present study, the efficiency of two inhibitors was tested (2-Dimethyletanolamine (DMEA) and 3-Aminopropyltriethoxysilane (APTS) added to the mortar mix. Chemical reagents of high quality ($\geq 99\%$) are compared with commercial inhibitors with the same chemical base. The fitting procedure was found crucial, because depending on where in the E/I curve the fitting was made, the inhibitors were efficient or not. To validate the polarization resistance measurements, the electrochemical weight loss was compared with the gravimetric weight loss. In addition, the steels were visually observed. The main conclusion drawn from the results, which are significant, is that the slope of the E/I curve must be measured in the linear range of the curve and not just on the previous potential.

CODE 301**EXPERIMENTAL STUDY ON BOND BETWEEN BASALT FRCM
REINFORCEMENT AND CALCAREOUS STONE**

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KEYWORDS: FRCM; Bond; Masonry.

ABSTRACT

Externally bonded reinforcement (EBR), such as FRCM (Fiber-Reinforced Cementitious Matrix) and FRP (Fiber-Reinforced Polymer) composites, represents an effective solution to strengthen existing concrete or masonry structures. In particular, FRCMs systems are considered a suitable alternative to FRPs when drawbacks associated with the use of organic binders could compromise the strengthening intervention. The studies reported in literature showed that FRCMs are effective in increasing the axial, bending and shear capacity of concrete members, as well as the in-plane and out-of-plane capacity of masonry walls, and the capacity of masonry arches. As well known, the effectiveness of composite reinforced materials is influenced by the bond behaviour at different interfaces. The bond depends on many parameters, e.g. bond length, mechanical properties of substrate and reinforcement, environmental conditions, etc. Differently from FRPs, for which the bond between fiber and resin is of chemical nature thanks to the polymerization process of organic matrix, the interaction between inorganic matrix and fibers is mostly of mechanical type. In fact, inorganic binders can hardly impregnate all fiber filaments, which leads often to a debonding phenomenon at the matrix-fabric interface. The paper aims to furnish a contribution to the understanding of the physical phenomena that characterize the mechanical behaviour of FRCM materials and their bond with masonry structures. Two types of substrates representative of the historical and artistic heritage of Southern Italy are considered reinforced with a basalt open mesh grid and two inorganic binders with different mechanical properties. In the following, the first results of the whole experimental program are presented and confirmed that the bond strength was influenced by both failure mode and kind of mortar.

CODE 354**THE IMPORTANCE OF THE “IN SITU” BEHAVIOR OF MORTARS
IN THE REHABILITATION OF BUILDINGS****Torres, Isabel^{1*}; Flores-Colen, Inês²**

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e-mail: ines.flores.colen@tecnico.ulisboa.pt**KEYWORDS:** Mortar; Support; Interface; In-service behavior.**ABSTRACT**

The coatings of the exterior facades of buildings are their protection, their “skin”, they are the elements that make the transition between the interior and exterior environment. They are the elements most exposed to various actions such as mechanical, chemical and climatic actions, among others.

The need for rehabilitation of a building involves, therefore, in most situations, the conservation / rehabilitation / replacement of the coverings of its external facades.

In almost all constructions, there is the presence, in greater or lesser amounts, of plastering mortar as part of the coatings of its facades. The necessary interventions on these mortars can range from a simple maintenance action to their total replacement.

Choosing a compatible rehabilitation mortar is a complex task and necessarily involves the knowledge, as rigorous as possible, of the existing mortar, its composition, its characteristics and even the characteristics of the existing support.

It is therefore essential to know the behavior of mortars in service, that is, after application on the various types of support, as this behavior differs from the laboratory behavior with which mortars are normally characterized.

The objective of the present work is to present the results of an ongoing research project – IF_MORTAR, carried out through a collaboration between Itecons and IST/CERIS, in which it was intended to characterize the behavior of mortars “in service” and to compare with the behavior of hardened mortars in laboratory molds, with the aim of contributing to a more adequate selection of rehabilitation mortars.

CODE 361**CHALLENGES IN SAFEGUARDING AND REHABILITATION OF
VILA VIÇOSA'S RELIGIOUS HERITAGE****Silva, J. Mendes¹; Ganito, Jorge²**

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e-mail: arq.jganito@gmail.com, web: www.uc.pt**KEYWORDS:** Vila Viçosa; Religious heritage; Safeguarding heritage; Rehabilitation strategies.**ABSTRACT**

Vila Viçosa is a town, located in Alentejo, in which its historical origin and human occupation is quite ancient, as evidenced by several archaeological testimonies, and the exploration of its marbles has been well known since at least the Roman period.

The urban consolidation of the current town was largely due to the Christian reconquest and the installation of the Agostinhos Convent (in which the church is currently the Pantheon of the Duques de Bragança) in 1267 and reached its peak with the singular and orderly urban expansion of the sixteenth century under the aegis of the Bragança Dukes, and this is the main reason for the current candidacy for the Inscription of an ancient nucleus and for the Royal cover on the UNESCO World Heritage List.

Religious buildings have an enormous importance throughout the urban context of Vila Viçosa, due to their location in the urban fabric, symbolism, quantity and architectural qualities. However, due to various vicissitudes of time and history, many of these buildings ended up entering in a process of disuse and degradation, accentuated over the past few decades. Therefore, it is urgent to know and revert this vacant state, through careful and informed methodologies, in the sense of preservation and valorization for future generations.

This investigation presents a contribution to the knowledge of this heritage, consisting of two dozen religious buildings of different types (convents, churches, chapels and hermitages), and of its state of conservation, with the aim of defining strategies and intervention methods that can guide a correct action on the existing built heritage and currently in the process of applying for World Heritage.

CODE 389**BEHAVIOR OF SUPPLEMENTARY CEMENTITIOUS MATERIALS IN ELECTRO
REMEDICATION PROCESSES APPLIED TO CONCRETE STRUCTURES****Martinez, Isabel^{1*}; Castellote, Marta²**

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e-mail: marta.castellote@csic.es, web: www.ietcc.csic.es**KEYWORDS:** Concrete; SCMs (Supplementary cementitious materials); Corrosion; Electro-remediation; ECE (Electrochemical Chloride Extraction).**ABSTRACT**

Corrosion of the reinforcing steel is caused by presence of aggressive substances in the interior of concrete that provoke a decrease in the pH of the pore solution. The penetration of chlorides from the environment is one of the most important causes of corruptions. To remediate chloride attack, electrochemical chloride extraction method (ECE) was developed for the repair of reinforced concrete structures subject to chloride-induced corrosion. The decision when to terminate the application shall be made according to more than one of the following: Chloride content, accumulative charged density and I_{corr} & E_{corr} values. In this point, an important gap was found by the authors. That is, a way to monitor its progress by non-destructive techniques is necessary.

On the other hand, nano particles of pozzolanic materials such as silica fume (SF), fly ash (FA) and granulated blast furnace slag (GGBFS) are commonly used due to unique characteristics of each material in improving the properties of cement concrete. The incorporation of mineral admixtures as SCMs can prolong the service life of a structure and contribute to its mechanical properties. Even though the influence of different mineral additions in the chloride combination and the diffusion coefficients of chlorides through concrete has been discussed by the scientific community, the effects of mineral admixtures on electro kinetic remediation processes have not been investigated in depth.

From this viewpoint, in this work the influences of, FA and GGBFS on the transport of chloride through the pore structure have been evaluated, leading to conclusions in the viability of the application of electrochemical chloride treatments in these materials and the way to monitor the process by electrochemical techniques.

CODE 403**DIFFICULTIES IN INTERVENING ON PROTECTED HERITAGE ACCORDING
TO PREFERRED STANDARDS OF REFURBISHMENT****Calderon Bello, Enrique¹**

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KEYWORDS: Heritage; Roof; Reinforcement; Spanish wooden trusses.

ABSTRACT

Although historically different trends have coexisted regarding how to intervene in the built historical heritage, in recent decades the tendency to preserve, consolidate and intervene in the most respectful way possible has ended up prevailing. Fortunately, invasive interventions are left behind, although even today we must face refurbishments in which we must repair a protected asset that suffered some interventions totally far from current criteria.

An example of this is the wooden roof of a chapel in Madrid, in which an unfortunate intervention, totally far from the current refurbishment recommendations, caused a change in its structural behaviour, causing damage to the rest of the protected building. After the specific study of the causes of the damage, a study of alternatives for reinforcing the roof was undertaken, proposing the typologies that could be approved with the greatest guarantee by the Commission for the Protection of the Historical, Artistic and Natural Heritage of the city of Madrid. (hereinafter CPPHAN). As shown in the case of the intervention, the multiple existing constraints, both in terms of design and execution, especially to guarantee the protection of the interior finishes of the chapel, forced us to choose a solution for the project that was not exactly the more evident when the study of alternatives began.

CODE 61**COMPARATIVE STUDY OF TECHNIQUES IN REINFORCED ADOBE FOR THE SUSTAINABLE RECONSTRUCTION OF THE COLCA VALLEY AFTER THE 2016 EARTHQUAKE****Cárdenas Gómez, José Carlos¹; Bosch González, Montserrat²; Damiani Lazo, Carlos³**

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KEYWORDS: Evaluation; MCDA; Reconstruction; Sustainability.

ABSTRACT

The research focuses on comparing six construction techniques: four in reinforced adobe and another two in masonry: confined and armed. For this, MIVES was used: Integrated Model of Value for a Sustainable Assessment, a multi-criteria decision-making model (MCDA). A methodology is proposed for choosing the most appropriate construction technique for the reconstruction of houses after a seismic disaster, in a rural and heritage context. It considers social, economic and environmental criteria that guarantee the sustainability of the intervention. The study was developed in southern Peru, in the Colca Valley that suffered an earthquake in 2016 that seriously affected the homes built.

The results show that reinforced adobe techniques are a competitive option, with respect to industrialized materials, because they are more economical, because they have the same safety characteristics, use traditional materials and techniques and better insulation against cold climates.

CODE 99

**STRENGTHENING OF FLAT SLABS WITH FIBRE REINFORCED POLYMERS
USING THE EXTERNALLY BONDED REINFORCEMENT ON GROOVES
METHOD: A REVIEW**

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KEYWORDS: Flat slab; Flexural and flexural-punching strengthening; FRP; EBROG; Externally bonded reinforcement.

ABSTRACT

The application of fibre reinforced polymer (FRP) composites has been proved to be an effective method for strengthening of reinforced concrete (RC) structures. The attachment of relatively light and high-strength FRP sheets on structural members can lead to a significant increase of the load bearing capacity without compromising the architecture or increasing the self-weight of the structure. However, the bond between FRP and the existing concrete surface remains the weak point of this strengthening system, often leading to an underutilization of the materials used for strengthening (i.e., failure occurs below the strength of FRP composites due to debonding of FRP from the substrate). Externally Bonded Reinforcement on Grooves (EBROG) is a technique that has been shown to improve bond between FRP composites and concrete while maintaining simplicity of application. In flat slabs, a concentration of stresses occurs near the supports, which can lead to a punching shear failure that has been shown to be catastrophic on several occasions in the past. This paper reviews different FRP flexural and flexural-punching strengthening methods that have been used for improving the punching shear capacity and behaviour of flat slabs subjected to gravity loading and focuses on the application of EBROG method by reviewing and summarizing the results from recently published tests. The efficiency of the EBROG technique in improving the behaviour of flat slabs is discussed and compared with that of the conventional Externally Bonded Reinforcement (EBR) method. The effect of flexural strengthening on punching shear capacity is discussed. The experimental results are used to apply the Critical Shear Crack Theory (CSCT) and gaps in analytical capacity assessment of FRP strengthened slabs are addressed.

CODE 100**MECHANICAL CHARACTERISATION OF VEGETAL FRCM COMPOSITES:
EXPERIMENTAL AND ANALYTICAL APPROACH****Mendizabal, Virginia^{1,*}; Bernat-Maso, Ernest²; Mercedes, Luis³; Gil, Lluís⁴**

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KEYWORDS: FRCM; Strengthening of structures; Vegetal fibers; Tensile test; Pull-out.

ABSTRACT

This work discusses the effectivity of using vegetal fibers as substitutes of synthetic ones on fiber - reinforced cementitious matrices (FRCM) and its potential as a solution for strengthening concrete structures. What is more, vegetal fibers are a potential substitute for synthetic fibers due to their low-cost, renewable and, lightweight composition. Two different fibers, cotton and hemp are selected based on their strength and deformation capacity. Pull-out tests were carried out to study the effect of epoxy resin coating on the adherence of the fibers to the matrix. Fibers coated with epoxy resin, yarns, and meshes, were tested under a tensile test. FRCM specimens were manufactured and tested in tension and numerical and analytical simulations were carried out. Coating vegetal fibers with epoxy resin, not also improved the interaction with the matrix, but also increased its strength, reaching similar synthetic fibers' strength. The deformation capacity of the vegetal fibers allowed the composite to present a more ductile behaviour, increasing the multi - cracking stage and delaying the failure point. Hemp specimens reached a higher strength and cotton specimens deformed more than 10 times hemp specimens. Both proved to be potential solutions for the strengthening of structures, especially in situations where dynamic loads are applied and a higher deformation is required.

CODE 152**EXPERIMENTAL AND NUMERICAL ANALYSIS OF THE CYCLIC IN-PLANE
BEHAVIOUR OF RETROFITTED MASONRY WALLS****Garcia-Ramonda, Larisa^{1*}; Pelà, Luca¹; Roca, Pere¹; Camata, Guido²**

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KEYWORDS: Cyclic shear compression test; Masonry; BTRM; FRCM; Macromodelling.

ABSTRACT

This paper presents an experimental study focused on the mechanical performance of retrofitted brick masonry walls under in-plane cyclic shear test. The specimens were tested in two configurations: unreinforced and retrofitted with Basalt Textile Reinforced Mortar (BTRM). The experimental programme aimed to study the suitability and efficiency of the solutions to increase the mechanical strength, the displacement capacity and the dissipation capacity.

In addition, an advanced numerical model was used for the analysis of the strengthened walls subjected to shear compression tests. The masonry was modelled as a continuous homogeneous macro model in which the nonlinear behaviour was described with a constitute model based on Continuum-Damage mechanics. The adopted model was able to capture correctly the main aspects of the observed experimental behaviour, such as initial stiffness, failure mechanism, and load-bearing capacity. The numerical results were compared with the experimental outcome to investigate the ability of the model to describe the in-plane behaviour of brick masonry walls retrofitted with BTRM.

CODE 160**DESIGN AND DETAILING OF ANCHORS FOR SEISMIC ACTIONS****Gramaxo, Jorge¹; Cardo Fernández, Antonio²**

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e-mail: antonio.Cardo@hilti.com, web: www.hilti.es**KEYWORDS:** Earthquake; Seismic Load; ACI 318; Cracked concrete; Anchor.**ABSTRACT**

In all parts of the world, seismic design methodologies not only for primary structures, but also including equipment, installation and other non-structural element supports have significantly gained in importance over the past years. In fact the economic and social costs associated with the failure or interruption of certain services and equipment such as water, energy or telecommunication supply systems and traffic lines are of comparable magnitude to the costs associated with structural failures.

As post-installed anchors are often used to fix these mentioned types of equipment, their adequate design is of crucial importance to guarantee safety and minimize costs associated with seismic events. This paper shows the working principles of different types of anchors, discusses their behaviour under seismic loads, and classifies them according to their suitability for the typical situations occurring in earthquakes such as large cracks in the concrete or alternating directions of the load.

The primary globally established design concept for anchors under seismic loads can be found in the US codes. This paper will describe the principles of the concept. Specific tests qualify anchors for seismic loads. ACI 318 gives a design method for qualified anchors. The main differences between this design approach and static anchor design are: In order to account for unpredictable influences such as crack width, the capacity is reduced by a reduction factor for seismic load; whenever possible anchors should be designed for ductile failure of either the attachment or the anchor bolt itself, and finally, if a brittle failure mode such as concrete cone pull-out controls, a further significant reduction of the design capacity is made.

As seismic loads are extremely difficult to predict with accuracy, good detailing practice is even more important than with well understood static loads. The final section of this paper will summarize examples of good detailing of anchorage applications leading to a cost-efficient enhancement of the overall safety of buildings and infrastructures in seismic events.

CODE 164**STEEL MESH REINFORCED COATING CHARACTERIZATION
FOR MASONRY UPGRADING****Crespi, Pietro¹; Cattaneo, Sara¹; Scamardo, Manuela¹; Vafa, Navid¹**

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KEYWORDS: Masonry retrofitting; Reinforced plaster; In-plane behaviour; Diagonal compression test.

ABSTRACT

Masonry buildings demonstrated to be vulnerable to earthquake events over the years, particularly due to their intrinsic brittle or poorly ductile behavior. Given the importance of masonry structures in the existing building stock, upgrading interventions aimed to increase the seismic performances of this kind of structures are of utmost importance. This paper will focus on the steel mesh reinforced coating technique. Despite its wide use, no detailed design approaches are available in codes or scientific literature to help designers defining the improved performance of the strengthened walls. To overcome this lack of knowledge, an experimental campaign on brickwork samples of both unreinforced and retrofitted walls was conducted. Cyclic diagonal compression tests under displacement control were performed considering different thicknesses of masonry and plaster. The obtained results highlighted the increase of failure load and ductility of the upgraded specimens with respect to the unreinforced ones.

CODE 172**POST-INSTALLED PUNCHING REINFORCEMENT DESIGNED BY
FIB MODEL CODE 2010****Kunz, Jakob¹; Cardo Fernández, Antonio²**

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KEYWORDS: Punching shear; Strengthening; Post-installed reinforcement; Fib model code 2010.

ABSTRACT

As punching shear is a brittle failure, design engineers usually pay great attention to this phenomenon when assessing the strength of existing structures. Visual inspection will in general not reveal signs of possible understrength. Nevertheless, when analyzing structures, it has been realized that many flat slab structures worldwide need strengthening. Reasons may be that the load requirements increased with modified use or that shear reinforcement was installed inadequately. Moreover, the knowledge about punching shear has significantly increased over the last few decades and therefore, even structures correctly built according to older codes may not comply with newer codes based on the latest state of the art.

This paper presents a method to enhance the safety of concrete slabs against punching shear failure by post-installed shear reinforcement. The reinforcement is bonded into inclined drilled holes from the bottom of the slab and anchored at the end by anchor heads. Compared to other methods, this has the advantages that the remedial work can be carried out from one side of the slab and that the dimensions of slab and columns are not modified.

A series tests has been performed to assess the effect of this method. In addition to the test results and their evaluation for a design concept, the paper will also present practical experience from projects where this system has been installed.

CODE 192**BILINEAR EXPERIMENTAL CURVE OF MASONRY WALLS MADE
WITH HORIZONTAL HOLLOW BRICK UNITS****Díaz, Christian¹; Tarque, Nicola^{2*}**

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e-mail: sntarque@pucp.edu.pe, web: www.pucp.edu.pe**KEYWORDS:** Strengthening; Welded mesh; Confined masonry; Horizontally hollow brick units.**ABSTRACT**

In recent decades, population density has increased in many Peruvian cities. According to the 2017 Peruvian census, more than 4.3 million dwellings are made with bricks or cement blocks. Although Peruvian Codes do not consider the construction of horizontal hollow brick units (HHB) walls because of their fragile behaviour, people use this type of bricks because they are cheaper than solid industrial bricks. Walls made with HHB units should be used only as partition walls and consider some confining elements. At least 60% of all confined masonry dwellings are considered non-engineered buildings, i.e. buildings with no engineering design or construction supervision and where the use of HHB load-bearing walls is abundant. In an earthquake of 8.0 Mw or more severe, many non-engineered buildings may collapse.

Then, it is crucial to evaluate the seismic capacity of walls made of HHB units and compare their lateral capacity and displacement ductility. Therefore, this paper collected and analysed a compilation of different in-plane cyclic experimental tests performed on masonry walls (HHB with and without external reinforcement) by Peruvian researchers. Subsequently, the authors proposed a bilinear curve for the HHB walls to be used in further analytical studies. Although there are some reinforcement alternatives for masonry walls, welded steel mesh is considered for comparison.

CODE 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****Kaddouri, Hajar^{1*}; Cherradi, Toufik²; Kourdou, Ibtissam³**

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KEYWORDS: Historical building; Unreinforced masonry structures; FRP; FRCM; Diagonal compression test.

ABSTRACT

Unreinforced masonry (URM) walls have proven to have low shear strength when subjected to in-plane loads caused by earthquakes. Since most masonry structures are not in compliance with current design codes, retrofit of existing URM walls is urgently needed to ensure their continued safe working conditions.

Recently, new materials such as Fiber Reinforced Polymers (FRP) and Textile Reinforced Mortar (TRM) were exploited for retrofitting solutions.

However, in the case of historical buildings, which require the fulfillment of specific preservation criteria, the use of inorganic matrix instead of epoxy resin is certainly of great interest, due to their higher compatibility with the substrate, especially on irregular surfaces.

This experimental work aims to evaluate the effectiveness of TRM overlays compared to that provided by FRPs. Five walls were tested under diagonal compression tests. One wall serves as a reference, the Alkali Resistant-Glass FRCM externally strengthened two walls on one or both sides, and the carbon or glass FRP retrofitted another two walls on one side.

The analysed parameters included the matrix material, the type of fibre and the symmetrical or unsymmetrical layout of the reinforcements.

The experimental results demonstrate the strengthening effect of FRCM and FRP systems on the shear behaviour of unreinforced masonry walls.

CODE 350**ON-SITE REHABILITATION OF DECAYED TIMBER FLOORS
WITH EPOXY-RESIN COMPOSITES****Bender, Tom^{1*}; Schober, Kay-Uwe²; Ihle, Robin³**

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e-mail: robin.ihle@googlemail.com, web: <https://www.zueblin.de>**KEYWORDS:** Timber floors; Rehabilitation; Strengthening; Composites; Decay.**ABSTRACT**

Renovation and restoration of historic timber floors in cultural heritage buildings can be challenging. Decayed beam-ends have to be replaced due to fungal or insect defects and on-site interventions can get expensive along with a loss of historical substance. Nowadays, two applications are commonly used: (i) Leaf joints, where the connection point is bridged with a wooden or steel leaf in a force-fit manner, or (ii) the BETA-system has been applied in many European countries, especially in England and Germany. The BETA-system is based on the replacement of damaged beam sections with wooden prosthesis, connected to the sound part by means of drilled-in fiberglass rods adhesively bonded with polyurethane resin. Although the quality assurance of the on-site bonding process can be a considerable problem. In addition, the limited workspace in many cases can lead to problems applying the reinforcement with accuracy.

Based on the experience with the deficits of those interventions, a new application system has been developed connecting existing floor beams and wooden prosthesis with epoxy-resin composites and low intrusion, efficient where working space is limited. The new concept represents a non-cost and non-time consuming technique, where decayed parts are attached to sound wood with epoxy-based mineral casting. Here, a notch is milled in the remaining sound wood from the top. The mineral casting of epoxy resin and fillers is placed into a slot and creates a frictional connection with the timber by means of full adhesive bonding. This fundamental importance of the overall performance has been approved by testing of matured and un-matured specimens. Further applications are inclined joints, e.g. the support of damaged rafters in the eaves area. For this purpose, plastic casings have been developed to prevent the adhesive grout from leaking. The formwork features a biomimetic surface structure and gives the composite an appearance like the historic original.

CODE 63**ARTISTIC BLACKSMITHING IN THE URUGUAYAN BUILT HERITAGE**

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KEYWORDS: Montevideo; Facades; Ornamental metal work; Craft; Conservation.

ABSTRACT

Montevideo, the capital of Uruguay, flaunts a variety of decorative elements on its building facades. These ornaments integrated into the architecture show a great formal and material diversity. Among them, the metallic elements are preserved in examples dating from the colonial era to the mid-twentieth century, testimony of the technical and artistic quality of our heritage. However, the existence of these handcrafted relics was not accompanied by an assessment through studies on their formal and symbolic characteristics in the field of art and architecture history, nor the enormous vulnerability to which they are exposed by virtue of their irreversible natural aging, the increasing deterioration represented by injuries caused by natural agents and lack of maintenance.

This presentation synthesizes the work carried out in the project “Iron and bronze. Criteria for the assessment and conservation of artistic blacksmithing in the Uruguayan architectural heritage”, whose objective is to establish the heritage attributes of the metallic ornamental elements on the architecture of this country and contribute to its dissemination, enhancement and conservation. The research has addressed the sociocultural, artistic, formal, technical aspects and those related to the deterioration of these elements, and has developed some guidelines for their preservation and restoration.

The work methodology was based on the study of written, graphic, edited and unpublished primary sources, on the review of specialized bibliography and also field work on a representative sample. In the course of the project, we registered a total of 600 ornamental elements belonging to 250 buildings. Two dimensions were observed: on the one hand their form, substance, applied techniques and state of conservation and on the other the artistic and decorative currents in which they are inscribed and their symbolism. Likewise, we researched the craft production processes and the historical evolution of the blacksmith trade in the country. The shared results make up an initial contribution in a field rarely addressed within the framework of Uruguayan architectural and artistic heritage.

CODE 195**RECOVERY OF A HISTORIC STAINED-GLASS WINDOW OF THE HOUSE
MAUMEJEAN IN SAN MARCOS 43 ST. MADRID**

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KEYWORDS: Stained-glass; Maumejean; Restoration.

ABSTRACT

During the rehabilitation works of a building commissioned by the Marques de Villatoya in 1873 and located at San Marcos st. 43, in the historical center of Madrid, the splendid stained-glass skylight that cover the main lobby of the building was completely restored. The research of the origin of this stained-glass skylight shows that it was manufactured approximately in 1920 by the House Maumejean. It is a magnificent example of the first civilian stained-glass windows of the early twentieth century. The state of preservation of the stained glass, revealed a huge deterioration due to unfortunate interventions and abandonment over the years. Due to the great aesthetic and functional value of this architectural space, an integral restoration was carried out based on the search of documentation on historical aspects and carrying out tasks of analysis and diagnosis of the damages. The restoration of the skylight was completed by the exterior with the elimination of the old and ineffective elements of protection and the installation of a truncated pyramid of polycarbonate and aluminum that acts as element of protection of the stained-glass against blows and dust. In this research, the recovery process of this valuable skylight is described, highlighting the complexity and importance of knowledge of the construction technique and the conservation of stained-glass skylight to help preserve this valuable legacy.

CODE 81**PROPOSAL OF SUSTAINABLE REHABILITATION OF INDUSTRIAL BUILDING
FOR INTERNSHIP AND TRAINING SPORTS CENTER****Lopes, Vera^{1*}; Iñigo, Miriam²; Lanzinha, João³**

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KEYWORDS: Covilhã; Architectural Rehabilitation; Urban Revitalization; Industrial Patrimony; Sustainability.

ABSTRACT

The city of Covilhã, in Portugal, known as Factory City as a reference to the strong wool industry of the past, has now several depopulated urban areas and a vast built industrial heritage unoccupied or in ruins. Currently, it's following the trend of occupation of surrounding areas, assuming these as preferential areas for construction, while urban centers are depopulated and existing buildings are being forgotten and abandoned instead of being valued and recovered.

After analyzing the urban context and the evolution of the industry, as well as the typologies related to industrial activity and constructive strategies for sustainable rehabilitation, a proposal of a project for the rehabilitation of one of the first woolen factories established in Covilhã is presented. The rehabilitation of the old industrial building intends to reintegrate it into the urban mesh and revitalize this area of the city, once one of the most dynamic and important in its industrial context. The project aims to relate the level of use of the existing construction, especially the resistant structure, with the need to adapt to a new use that offers attractiveness and dynamism to the city, introducing principles of sustainable construction. Through the development of an Internship and Training Sports Center program, the tendency to consider cultural or commercial programs is contradicted and the flexibility of rehabilitation and adaptation of this type of building is exemplified.

The potential for sustainable rehabilitation of the built industrial heritage is highlighted, with the possibility of adapting to new programs and any function, without compromising its structural, aesthetic or formal integrity, thus preserving its identity and values. The rehabilitation of these buildings increases their heritage value and ensures their proper functioning while also ensuring improvements for the future through the application of sustainable construction solutions, relating to environmental issues that currently arise in the field of architecture and construction. The identified solutions and strategies aren't just for the presented proposal but serve also as a reference for other cities and heritage in similar conditions.

CODE 267**EXAMINING THE DEFECTS AND INTERVENTIONS IN THE COMPONENTS OF
REUSED INDUSTRIAL BUILDINGS-CASE OF TURKEY****Çakır, H. Yasemin^{1*}; Edis, Ecem²**

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e-mail: ecem@itu.edu.tr**KEYWORDS:** Industrial buildings; Adaptive reuse; Defect; Building components; Intervention.**ABSTRACT**

In the 18th century, the developments in the field of production technology which is called the Industrial Revolution caused many changes and new facilities were built by following per under changing production processes, while the others became idle. However, in the 1960-70s, conservation of these facilities gained importance since they reflect their periods' characteristics. In this context, reuse is seen as one of the suitable methods both to protect their knowledge and to ensure continuous use and maintenance.

During the reuse process, interventions can be made to eliminate the defects and previous interventions, and to fulfil spatial and physical requirements of the selected new function and users. Through these purposes, interventions are made at the scales of building, element, and component. Within the scope of a master study, interventions made in the reuse process of 15 industrial facilities in Turkey were examined in these scales and their relations with the selected function were evaluated. In this paper, seven of these facilities and their 16 blocks adapted from 'food, beverages and tobacco manufacture' and 'water works and supply' to cultural centre, museum, and education functions are considered to examine component scale interventions. Relatedly, interventions collected from restitution, survey, and restoration projects and reports are evaluated under (i) maintenance and repair, (ii) consolidation and strengthening, (iii) to meet performance requirement, and (iv) other interventions categories by associating with too.

Analyses showed that the frequency of these interventions categories decreases in the given order in these case blocks. Since all blocks have registration and masonry structural external wall, maintenance and repair interventions gain importance to repair defects and turn blocks their original state, but interventions to meet new function's performance requirements are less due to a thick external wall. The elements and components where the interventions were mostly implemented are the roof and masonry structural external wall, and core and finishing layers, respectively, which are open to climatic conditions.

CODE 279**ANALYSIS OF THE FRENCH TRAIN SYSTEM IN A SUGAR MILL OF THE 18TH CENTURY ON THE ISLAND OF SANTO DOMINGO AND RESTORATION CRITERIAS****Prieto-Vicioso, Esteban¹; Flores-Sasso, Virginia²**

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KEYWORDS: Sugar mill; French train; Boca de Nigua; Santo Domingo; 18th century.

ABSTRACT

The cultivation and production of sugar cane (*Saccharum officinarum*) began in the New World in the 16th century on the island of Santo Domingo, where hydraulic sugar mills and blood or animal-driven mills were built. At the end of the 18th century, a sugar mill was built near Santo Domingo, on the banks of the Nigua River that used the French train system modified by Paul Belin de Villeneuve, which consisted of heating four lined up kettles of the same size, ending in two smaller ones, equal to each other, which had the same capacity as one of the larger ones, using a single fire, fed by firewood and dry bagasse from the sugar cane. This new procedure represented a great saving of wood and increased production speed. The Boca de Nigua mill has a boiler house with two production lines, a trapiche to be moved by animals, a purge house, a warehouse and a large lime kiln. The desing used for the construction of the mill is described and drawn in the book "Traité sur les propriétés et les effets du sucre", published in Paris in 1789, which indicates that it was for a mill in Saint Domingue. This document was used to restore the mill in the second half of the 20th century. It was decided to rebuild half of the boiler house and the purge house, taking advantage of the existing symmetry in both buildings, preserving the consolidated vestiges in the other half. The objective of this article is to analyze the French train system of the Boca de Nigua mill and the criteria used in the partial reconstruction of the mill.

CODE 17**REHABILITATION OF THE ACCESS TO THE SAN JUAN DE
GAZTELUGATXE HERMITAGE****Baraibar, José Manuel^{1*}; Escobal Marcos, Iñigo¹**

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e-mail: jmbaraibar@viudadesainz.com, web: www.viudadesainz.com**KEYWORDS:** Hermitage; Masonry; Vertical works; Helicopter.**ABSTRACT**

The hermitage of San Juan de Gaztelugatxe dates back to the 9th century. Over the centuries, due to different events, this church has had to be rebuilt on many occasions. Because of its historical interest, because it is located in a protected biotope and forms part of the Natura 2000 network and because it has been the location of some scenes in the Game of Thrones series, the number of visits to the area has increased exponentially in recent years, which has forced the Provincial Council of Bizkaia to limit the daily number of visitors and to condition its accesses, as some elements of the path to the hermitage area were seriously degraded by the effect of time and the erosive action of the sea.

A project to restore the accesses was planned with the aim of increasing the resilience of the elements involved. The aim was to repair the stone parapets and the unevenness and lack of support of the walls that make up the access path to the hermitage, as this lack of continuity endangered the transmission of forces on the masonry walls, increasing their risk of collapse.

The rehabilitation techniques that have been implemented seek to reconstruct the masonry in a similar way to the original walls, using materials from the surrounding area and sulphur-resistant mortars. The great challenge has been the difficult conditions of access to the pits and the transfer and transport of materials. Many of the repairs had to be carried out using rope access techniques and most of the material had to be transported to the site by helicopter.

The rehabilitation campaign of the accesses to the San Juan Hermitage has been carried out mostly with unusual techniques for this type of work (rehabilitation with climbers and the use of a helicopter to carry the materials to the foot of the pit). These actions have made it possible to consolidate unstable areas of the path to the hermitage and give visual uniformity to the surroundings, restoring its original harmony.

CODE 24**INTEGRAL RECOVERY OF THE HERMITAGE OF
SAN BLAS IN BROTO-HUESCA****Febas Borra, José Luís¹; Díez Hernández, Jesús²; Rojí, Eduardo³**

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e-mail: eduardo.roji@ehu.es**KEYWORDS:** Hermitage; Heritage; Association; Integral Recovery.**ABSTRACT**

The works that, after seven years guided by the Association of Friends of Broto and its Valley, have led to the integral recovery of the Hermitage of San Blas in Broto-Huesca, are presented.

On the left bank of the Ara River and bordering the urbanization "Nuevo Broto", from which the ravine of Arán separates it, is the hermitage of San Blas, the oldest building in the town of Broto. It is a small temple with a Latin cross plant, which lacks the north arm, and an elongated nave raised on solid base to save the existing slope at the foot of the temple. Its constructive typology denotes several phases in its execution, ranging from before the twelfth to the seventeenth century. Its poor state of conservation motivated the Association of Friends of Broto and his Valley to undertake the procedures for their recovery.

The temple initially lacked electric light, the roof structure was seriously deteriorated, damages in the wall fabric, the carpentry was in poor condition, the exterior walls and roof were overrun with vegetation and in the absence of rejoining material. Finally, the surrounding land was not minimally urbanized and had no access under minimal conditions.

For this reason, it was necessary to undertake the work of rehabilitation of the hermitage, work of interior and exterior adequacy to solve the structural and moisture problems, as well as condition the hermitage for use with the conditions of health and access due.

The general criterion of the intervention has been to respect as far as possible all the valid elements of the initial state of the hermitage, the result of the multiple actions of which it has been subjected throughout its almost millennium of existence, in line with the rest of the hermitages of the valley with only occasional worship.

The article contains the description of the hermitage, the approach and the conduct of the studies, the work carried out, and the result that has finally been reached.

CODE 80**MODEST HERITAGE PRESERVATION IN SAN SALVADOR HISTORIC CENTER.
THE GREEN HOUSE REHABILITATION CASE****Avendaño, Ayansi¹**

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KEYWORDS: Cultural Heritage; Rehabilitation; Wood Architecture; Iron Architecture; San Salvador Historic Center.

ABSTRACT

At the end of the 19th century and the beginning of the 20th century, in El Salvador occurred a significant change from the earth construction tradition, to the use of wood and iron sheets as a modular and light material for architecture, that were imported from Europe and the United States, because they were considered by the Salvadoran State of that time as an ideal construction system given the high seismicity of the country.

The construction system is characterized by its easy adaptation to any architectural program and stands out because of its use in residential houses, where significant formal and technological experiments were developed from the wooden structure, covered by die iron or zinc sheets, deployé or by tongue and groove wooden slats.

Few of these buildings are currently preserved, facing a greater danger of disappearing due to the pressure of urban development, the ease of disassembly and the institutional weakness to protect them, in addition to the loss of traditional techniques.

This presentation shows the proposal for the rehabilitation for one of these modest buildings with cultural value known as La Casa Verde, located in the current CHSS (Historic Center of San Salvador), based on the analysis and interpretation of the singularities of its original construction techniques, materials used and especially its spatial configuration, to turn it into homes for low-income families organized in a Cooperative of Housing for Mutual Assistance, thereby contributing to the conservation of this heritage, allowing it to be adapted to the needs of the current community and future society, but without jeopardizing its authenticity and integrity.

CODE 83**LIGHT AND SPACE - TRANSFORMING A VILLA INTO THE
CHRISTIAN YOUTH CENTRE TIMISOARA****Andreescu, Ioan^{1*}; Dinu, Dan - Răzvan²**

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KEYWORDS: Rebooting; Restoration; Extension; Light; Space.

ABSTRACT

The modernist, late 1920's villa is situated in an elegant residential area in central Timișoara (Romania). It stands back-to-back to the valuable ensemble of the local archbishopric. The project is about rebooting the damaged villa, expanding it and transforming it into a contemporary Youth Centre. The concept runs on two threads. First, the preservation of the appearance of the villa by retrofitting the concrete structure and restoring both the interior and the exterior. The nearby presence of the intact twin villa offered precious insights. Second, the villa was extended with a „suspended” new auditorium, connected to the small archbishopric garden via a landform. This transitional space will host events, meetings and casual interactions. The new space is endowed with an ample stained-glass wall, overlooking the garden, created by a noted artist: Orăvitza. The work will be enhancing a particular aspect of the interplay between light and space: solar light („Lumen”) vs. symbolic, un-created light („Lux”). The cooperation between architect and artist in order to obtain a fully integrated work of art was complex but rewarding. Light must be treated carefully using the best materials and technology. The main goal of the new space was to create a bridge between old and new, between the closed world of spirituality and the open world of the contemporary youth. It is a one-of-a-kind project recreating an entire ensemble, giving new life to a beautiful heritage building, promoting links between worlds using the magnificent interplay of light and space.

CODE 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**

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KEYWORDS: Faculty of Economics; Roof; Examples of intervention; Architectural rehabilitation; Modern and contemporary architectural heritage.

ABSTRACT

The Faculty of Economics and Business Studies is located in the heart of Seville's city centre. Its initial project dates back to 1973, and was drawn up by the Sevillian architects Fernando Villanueva Sandino and Gonzalo Díaz Recaséns. Almost twenty years after its inauguration, it was renovated and extended by the latter after the death of his partner.

At the beginning of 2020, the roof of the main courtyard of the Faculty, a singular vaulted element and spatial area in the complex, after having undergone various repair and ordinary corrective maintenance actions throughout its life, was in a critical state, making it necessary to carry out a larger-scale intervention that would allow it to recover the functional, safety and habitability conditions that were inherent to it. In May 2020, the University of Seville put out a call for tenders to repair the roof.

This is an intervention on modern architectural heritage, in which the proximity in time of its construction and the absence of superimposition of historical strata propitiate a novel approach, where reflection on the original ideas of the project is incorporated as a new heritage value.

The objective of this work is to present an example of a singular intervention characterised by the possibility of studying and getting to know its author, the project idea and the analysis of the technological and constructional revolution that its materialisation implied, with the opportunity of relying on the memory of its users and its author for this purpose.

The solution of the intervention developed from the replacement of the covering pieces of the building's central courtyard to ensure watertightness and natural lighting conditions, as well as the damp-proofing of adjacent galleries and the cladding and fire protection of the structure.

The methodology followed was based on the compilation and study of the historical and technical background of the building, the contribution of considerations from the project, with regard to the recognition of the heritage values of the architecture to be intervened, and from the analysis and monitoring of the work and the construction systems used, in relation to its enhancement, based on the principles for the analysis, conservation and restoration of architectural heritage structures, drawn up by ICOMOS and included in the Krakow 2000 Charter.

CODE 115**TECHNOLOGICAL REFURBISHMENT AND ENERGY RETROFIT OF LARGE, FLAT ROOFS BY USING METAL SHEET SYSTEMS: THE CASE STUDY OF A MULTIFUNCTIONAL BUILDING**

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KEYWORDS: Flat roofs; Energy refurbishment; Roofing systems; Standing seam; Photovoltaic integration.

ABSTRACT

Flat roofs in architecture are particularly suitable for large buildings such as factories, warehouses, or exhibition halls. Metal sheet roofing systems generally allow to reach slope pitches down to 1%, without compromising the global water-tightness. However, since achieving such performance requires an accurate and experienced design to guarantee a full integrity over the years, the actual roofs service-life is, in often cases, significantly reduced to a much shorter period than expected, possibly leading to the need of a substantial refurbishment to definitively solve problems mostly related to water seepage. Considering the need for refurbishment of a large part of the industrial building heritage, such circumstances can be an opportunity to pursue an energy refurbishment by the improvement of the thermal/hygrothermal performance of the roof and, eventually, also the integration of photovoltaic panels. While waterproofing membranes might be not the most appropriate solution (considering roof dimensions and complex geometry), standing seam roofing systems are a versatile solution which is particularly suitable for large, flat roofs, as they fully comply with the lightweightness requirement typical of large-span structures, guaranteeing an adequate load bearing capacity and wind resistance at the same time. The paper investigates a significant case study of an energy and technology retrofit of a large, flat roof covered with a standing seam system, eventually integrated with a large-scale solar power plant. In particular it examines the previous pathologies occurred and discuss the design of the new roof layouts, slopes pitch, and construction details, also showing the experimental tests conducted to better define the best design solution.

CODE 118**REHABILITATION OF THE TXATXARRAMENDI BRIDGE IN BUSTURIA-SUKARRIETA (BIZKAIA)**

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KEYWORDS: Bridge; Rehabilitation; Concrete; Biosphere Reserve.

ABSTRACT

The bridge that connects Busturia with the island of Txatxarramendi has an approximate length of 108 meters and saves the Bilbao-Bermeo railway line as it passes through Busturia, as well as the Gernika estuary, to give access to road and pedestrian traffic from Busturia to the island of Txatxarramendi. The bridge, built approximately in 1943 with reinforced concrete, is formed by six spans, three of them over the Gernika estuary, Urdaibai Biosphere Reserve since 1984.

The marine environment in which the bridge is located has favoured the appearance of various damages in it, mainly related to the existence of moisture in the concrete and oxidation of both the armatures and the supports of the board on the piles. The location of the bridge, in the Urdaibai Biosphere Reserve, as well as the existence of a railway line under one of its spans, make it necessary to undertake the inspection and repair of the bridge, with extreme safety conditions and respect for the environment.

The works carried out on the Txatxarramendi Bridge from 2006 to the present are presented, which include studies of the state of the structure, repair actions and rehabilitation projects.

The article includes the history and description of the bridge, the results of the studies carried out on the structure, the repair actions carried out and the content of the rehabilitation projects drafted.

CODE 175**MEMORIES OF IMMIGRATION - THE RESTORATION
OF THE HOTEL LANFREDI**

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KEYWORDS: Immigration; Cultural heritage; Restoration.

ABSTRACT

The knowledge and recognition of assets that are part of the local daily life as cultural heritage guarantee their appropriation and appreciation by the community, which in turn will become an ally in the actions of preservation and conservation of this heritage. Within this logic, the proposal to restore the Hotel Lanfredi aims to transform it into the “Casa da Mulher Imigrante” (Immigrant Woman's House) and, with that, to rescue the memories of the local residents, descendants of immigrants, in relation to the female figure of immigration, and at the same time, give the welcome to visitors arriving in the municipality, due to its strategic location at the entrance of the city. The property was built in 1903, by João Weissheimer, for residential and commercial use by the family, which makes it a landmark of immigration in Vale do Caí and its cultural influences transmitted to the present. It is a masonry townhouse with an approximate built area of 500m², installed on an ideal fraction of land of 2,810.04m². The interior of the building is quite modified, however the facades remain very close to their original version. With the restoration and availability to the public as cultural equipment, it will be a memory center for immigrant women, capable of expanding the notion of belonging and cultural significance of society. The proposed intervention in the listed property, the design decisions and its theoretical basis are presented throughout this article.

CODE 178**THE RESTORATION OF SANTA CRUZ CHURCH IN ECIJA (SEVILLE):
THE BUILDING AS PLOT**

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KEYWORDS: Built heritage; Refurbishment methodology; Master plan; Case study; Diagnostic techniques.

ABSTRACT

The complementarity between the documental and constructive analysis of the heritage object is a key process to guarantee the adequate intervention in it. In this paper, this dual methodological view is applied to the diagnosis and restoration of the case study of the Main Church of Saint Cross in Écija, Seville. The owner of the property, the Archdiocese of Seville, commissioned in 2018 the development of a Master Plan of the property as a means to identify, design, arrange and manage the multiple interventions this group of buildings require due to their large dimensions, deficient conservation status and various damages. The church also presents needs beyond the conservation of its constructive systems, especially at a functional level. It also requires a historically pending reflection about the naves that remained uncovered by the neoclassical intervention of the church, today in a precarious conservation status. During the drafting process, an intervention on the wooden structured roof and its tiled roof is designed and executed, which require an urgent intervention due to their advanced deteriorating state. These works are partially executed between 2020 and 2021. The results of the research and the recovery works of the structural systems, the roof's enclosure and ornamentation, are set out in this contribution. The works have provided plentiful information and knowledge of the building and its structural system, that will also support the structural and architectural pending decisions for the completion of the Master Plan's drafting phase, reinforcing the idea of the Master Plan as a living and dynamic element and the building itself and its nature as the best project's argument.

CODE 223**ANALYSIS OF LEAN CONSTRUCTION INFLUENCE IN BUILDING PROCESSES
USING BIM 4D: CASE STUDY****Ferrer, Pedro A. M.¹; Ribeiro, Rodrigo S.²; Oliveira, Rui A. F.³**

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e-mail: roliveira@ipb.pt**KEYWORDS:** LEAN Construction; BIM 4D; Metallic structure; Schedule Time; Building.**ABSTRACT**

Construction is a sector since antiquity and with great importance to societies. The quality of construction works involves several processes and stages which must be managed correctly. During construction works of a building with LEAN construction assumptions, there are some processes possible to improve carry out a great efficiency, productivity, and consequent work control.

Following the philosophy of LEAN, together with the use of BIM 4D tools, it is possible to detail the work in a virtual and digital way, adding the time schedule of the resources in the work process, making its execution status almost in real-time, comparing against the estimated deadline.

The paper uses the BIM 4D technology of Autodesk's REVIT and Navisworks software, based on the assumptions of LEAN construction, applied to a case study of a building rehabilitation work of a metallic structure. The use of the Microsoft Project software allows the development all work planning to be added in the 4D dimension in the BIM software applied.

The results show a relationship between time schedule reduction in different work execution processes and the assembly of the metallic structure. And also when applied the concepts of LEAN construction show considerable improvements compared to the conventional processes that were found in a real situation of this work.

CODE 225**PLANNING AND MANAGEMENT OF AGRICULTURE WAREHOUSE
CONVERSION PROJECT: A CASE STUDY****Oliveira, Rui A. F.¹; Abreu, Maria Isabel²; Lopes, Jorge³**

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1: e-mail: roliveira@ipb.pt2: e-mail: isabreu@ipb.pt3: e-mail: lopes@ipb.pt**KEYWORDS:** Conversion project; Management; Planning; Time; Work; Project.**ABSTRACT**

Planning and scheduling are crucial activities for the successful development of a construction project. Occurrence of unexpected events, which are prevalent in the construction industry activities, can have a negative impact on the development of a project even with the use of up-to-date risk management techniques.

This paper deals with the investigation of planning activities in the design phase of a building project, by analysing the project's bills of quantities, unit rates drawn from construction cost data, project duration, and construction works tasks pertaining to the conversion of an agriculture warehouse to a chapel dedicated to the Santíssima Trindade.

Two different approaches for the project duration determination were considered: i) data obtained from interviews conducted on five representatives of building contractors; ii) the duration of the project and respective construction tasks were calculated based on unit rates analyses obtained from construction cost data. These different approaches for the definition of the project duration made it possible a better determination of the time limit for the completion of the building works.

The project had some technical complexity, especially in project design specialties coordination and technical areas, such as subcontracted works and their articulation with sculpture works' activities. The weighted solution applied in the project design phase was deemed correct, well managed, and the evidenced risks were controlled. The elimination of design failures, timely management of contingencies, constraints reduction, project duration, and time limit under control had a positive contribution to the completion of the execution phase of the project in 57 working days. This study also compares the planning schedules for the different scenarios analysed with the real-time data pertaining to the conversion construction works.

CODE 228**THE ROOF OF THE SANTA LUCIA CHURCH - FERREÑAFE: INTERVENTIONS
FOR THE MAINTENANCE OF THEIR STRUCTURAL AND FUNCTIONAL
INTEGRITY****Chirinos, Haydeé^{1*}; Zárate, Eduardo²; Beltrán, Freddy³**

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KEYWORDS: Religious architecture; Viceregal; Conservation; Peru.

ABSTRACT

This research focuses on the heritage architecture of Ferreñafe, an ancient indigenous village on the north coast of the viceroyalty of Peru. The Santa Lucia Church was declared a historical monument of the nation in 1972. It is an exempt building whose uniqueness lies in its local stylistic expression with baroque influences and, in being the result of a sequence of interventions over time, with different construction techniques, both colonial like republican, among it can see the adobe masonry on the walls, the wooden and cane structures on the roofs and some minor brick vaults.

This article presents the results of a historical review about the building and a look at its architectural conformation, as well as the presentation and interpretation of the process of the latest interventions carried out on its roofs due to the urgency of its stability in the face of the effects of the rains (El Niño - Southern Oscillation) and its state of deterioration caused by the lack of maintenance and timely reparation.

In the intervention process, studies of prospecting, surveying and data analysis were carried out. Finally, the maintenance of the supporting structure was executed, replacing the external roofs on the wooden vault that covers the nave and the presbytery and the flat lateral roofs adjacent to it.

The limitations were related to the limited time available before the rainy season, so the "as built" system was used, each phase had the -in situ- participation of all the actors. Also, limitations were linked to the design criteria of the interventions, whose premise was to preserve the original both formally and materially, preserving the original spirit of the building.

The methodology for this research and the presentation of the interventions are based on architectural and constructive surveys, in situ observation and data analysis.

CODE 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****Videla, José Tomás^{1*}; Huenchuñir, Marcelo²; Bustamante, Fermín³; Martínez, Patricia¹**

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e-mail: fbustamante@4darquitecto.cl, web: www.4darquitecto.cl**KEYWORDS:** Conservation of industrial heritage; Energy retrofit; Sustainable design; LEED certification.**ABSTRACT**

This case study aims to demonstrate the feasibility of integrating structural intervention and thermal reconditioning criteria in heritage buildings in Chile, and to point out some local methodological gaps in energy evaluation, thereby aiming to strengthen the environmental and economic arguments to promote and finance this type of public investment projects in the country. The study deals with the case of the new public court building in the city of La Serena, with 10,456.67 m² built in an old reinforced concrete industrial building, declared a historic heritage building and located in a historic district. In addition, the project had to incorporate Sustainability and Energy Efficiency standards, certifiable with the LEED© system of the USGBC. The implementation of these measures involved the demolition of floor and ceiling slabs, and some columns, as well as the removal of an entire floor level, in order to free up the architectural floors to accommodate new uses, and to have more natural lighting and ventilation. Although this entailed significant design and construction challenges, also considering the seismic condition of Chile, the models and simulations foresee a reduction in energy consumption of almost 50% and an increase in indoor environmental quality conditions, which will have a positive impact on the operation of the building in economic, social and environmental terms. The case study also demonstrates the relevance of advancing in the standardization of technical-regulatory aspects of structural reinforcement that are compatible with the thermal and lighting improvement of buildings, and of methodological aspects in the energy and cost-benefit evaluation of thermal conditioning in existing buildings.

CODE 259**THE GOTHIC OF THE TWENTIETH CENTURY IN COLOMBIA. RESTORATION
PROJECT OF THE CHURCH OF THE INMACULADA CONCEPCIÓN IN
CARAMANTA, ANTIOQUIA****Carvajal Jaramillo, Henry H.¹; Ochoa Botero, Juan C.²**

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e-mail: jcochoa@unal.edu.co, web: <https://unal.edu.co>**KEYWORDS:** Neo-gothic; Religious architecture; Latin American architecture; Colombian architecture; Restoration.**ABSTRACT**

This paper collects the results obtained in the restoration project of the church La Inmaculada Concepción in the Municipality in Caramanta in western Colombia. The church appears as a social and symbolic vestige of the well-known Antioquia colonization and is part of the set of architectural and urban projects of the Belgian architect and engineer Agustín Goovaerts, who lived for eight years in Colombia, at the beginning of the 20th century. The building expresses a neo-Gothic style adapted to the technologies and conditions of the place. The aim of this work is to show how, through interdisciplinary work, the premises of critical restoration, and the contact with the community, it is possible to establish and apply objective restoration criteria, respectful of the building, with its use and its meaning. Despite not being cataloged on the lists of goods of cultural interest at the national or regional level, this work manages to put it in value and give it a new meaning for the people in the place. Likewise, it manages to discover the importance of the religious building for the region, its construction systems, its architectural, structural, and functional state of conservation and to propose an appropriate intervention proposal with the aesthetics, style, and socioeconomic conditions of the region.

4.- MAINTENANCE

4.1.- CONSTRUCTION MAINTENANCE AND INFRASTRUCTURES.

4.2.- PREVENTIVE CONSERVATION OF BUILT HERITAGE.



CODE 21**COVID-19 LESSON ON FACILITY MANAGEMENT OF PUBLIC BUILDINGS****D'Orazio, Marco¹; Bernardini, Gabriele²; Di Giuseppe, Elisa³**

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KEYWORDS: Covid-19; Facility management; Data mining; Maintenance.**ABSTRACT**

The emergence caused by the COVID-19 pandemic caused a strong impact even on people interaction with building environments. Public buildings were closed, while the regular access to public and private offices, industries and schools were significantly limited, requiring a quick transition towards different organizations. To reduce the number of people inside the buildings, web services were enhanced, and the practice of smart-working was extended. Nevertheless, during the pandemic, most buildings were normally left open, to allow the regular functioning of the services necessary to ensure smart-working and the necessary changes to HVAC systems to improve ventilation. Pandemic obliged facility managers to change operational and maintenance plans, mainly given the increase of HVAC requirements and the reduction of other types of services, with an important impact on building Operation and Maintenance (O&M) cost and previously defined maintenance strategies. This contribution analyses the impact of the pandemic on operation and maintenance activities on 20 buildings, part of the building stock of Università Politecnica delle Marche (Italy), using data mining approaches. About 12000 end-users' maintenance requests, generated after and during the different phases of the pandemic, were analysed and information about the change in facility management (FM) activity was collected, to understand how the post-pandemic use scenario will impact the O&M (type and amount) and consequently how to improve FM outsourced contracts.

CODE 32**INFLUENCE OF THE USERS' PERFORMANCE CRITERIA ON THE IMPACT OF MAINTENANCE OF CERAMIC CLADDINGS****Cláudia Ferreira¹; Ana Silva²; Jorge de Brito³**

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KEYWORDS: Maintenance; Users' performance criteria; Ceramic claddings; Petri nets.

ABSTRACT

Maintenance actions are often conditioned by subjective criteria related with how the buildings' degradation is perceived by users and owners. The reasons beyond users performing maintenance actions can have social, economic, cultural, and community dimensions. The decision to intervene is intrinsically related with the capability of the building and its components to fulfil the users' demands and expectations. The acceptance criteria vary from neighbourhood to neighbourhood, and over time. This study discusses the influence of the users' acceptance criteria to establish the need of intervention in ceramic claddings. For that purpose, different acceptable degradation levels are defined, to characterise the degradation conditions of ceramic claddings and the end of their service life, according to the users' demands and funds available for maintenance actions. The influence of the users' criteria on the impact of maintenance of ceramic claddings is analysed and discussed, considering different maintenance strategies. In this analysis, four parameters are considered: i) the performance of the claddings over time; ii) the costs of the maintenance actions over the claddings life cycle; iii) the number of replacements; iv) and the estimated service life of the claddings. Finally, this study provides some guidance regarding the selection of the best maintenance strategy, according to different users' acceptance profiles.

CODE 51**METHODOLOGY FOR IMPROVING THE EFFICIENCY OF INVESTMENTS IN THE VARIOUS INDUSTRIAL INFRASTRUCTURES OF THE FORMER PORT AREA OF THE BAY OF HAVANA**

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KEYWORDS: MIVES; Historical heritage; Prioritization; Rehabilitation; Port infrastructures.

ABSTRACT

Since 2002, the Office of the Historian of the City of Havana (OHCH) and TECNALIA have worked continuously and jointly on a common strategy to manage the rehabilitation and conservation of the Historic Center of Old Havana.

The Historic Center of Havana, declared a World Heritage Site by UNESCO in 1982, has an area of 2.14 km² and consists of 3,510 buildings, which are subject to permanent degradation. In 2012, Tecnalia carried out, together with Plan Maestro coworkers, a methodology for prioritizing rehabilitation actions, which has led to a great improvement in the procedures aimed at inspection and decision-making.

The Bay of Havana and the port have long been the engine of development of the city and the country. The government decision to move a large part of the commercial activities of the Havana port to Mariel, 60 km to the west, after its inauguration in 2014, reveals a large number of obsolete industrial infrastructures in need of maintenance and with a high risk of abandonment or demolition. These large industrial and storage areas have extraordinary cultural, natural and landscape potential that, through reconversion and reuse processes, can lead to new uses, transforming them into leisure, recreation and service areas for the city and its inhabitants.

That is why a new methodology is currently being carried out aimed at prioritizing the necessary interventions of the old port infrastructures of the Historic Center located next to the Bay and which refers to the need to address sustainable rehabilitation that contributes to the recovery of this area of high historical and cultural value through the creation of an innovative work tool that facilitates prioritization of the reconversion and new uses for the benefit of the population.

CODE 69

A NEW METHODOLOGY FOR RAILWAY BRIDGE INSPECTION FROM OPTICAL IMAGES AND HD VIDEOS OBTAINED BY RPAS

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KEYWORDS: Construction maintenance and infrastructures; RPAS; Bridge inspection; Damage structures.

ABSTRACT

In this work, a methodology for bridge inspection is proposed using optical images and HD videos obtained from a short distance from all critical parts of railway bridges. The workflow begins with the image and video acquisitions by Remotely Piloted Aircraft System (RPAS) flights, which allow to access to the upper parts of the bridges safely and without traffic disruptions. Afterwards, the images are studied by civil engineers for damage identification and description. Some inspection sheets designed for bridge inspection are filled in while watching the videos. Finally, if necessary some recommendations about the need of new and more detailed inspections should be stated. Moreover, it is recommended to systematize the order of image recording in a bridge inspection. For that reason, the systematization of data gathering for routine visual inspections based on drones' observations has been proposed. In order to evaluate and validate the application of the proposed methodology, it has been applied to two case studies on two railway bridges in France. For this purpose, image acquisition of these railway bridges has been performed using an RPAS for their subsequent expert judgement to state a preliminary evaluation of the damage level. This method has the main advantage that it makes it possible to identify safely, accurately, and without the need that a specialized engineer goes on site, diverse damages in structures. Moreover, the videos can be watched by as many engineers as needed without any personal movement. In addition, the drone operator can record the images as he does for other railway inspections such as the catenary wire, insulators, etc. On the other hand, it is important to note that this methodology is easily exportable to other linear infrastructures where the same elements have to be inspected. In addition to the advantages described above, we could add the fact of being able to minimize displacements in pandemic situations since the flight can be performed by only one person. In other words, the scheduled maintenance of the structures continues to be guaranteed without risking the health of the engineers.

CODE 85

FEASIBILITY ASSESSMENT OF WORKING AT HEIGHT EQUIPMENT, IN RESIDENTIAL BUILDINGS MAINTENANCE

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KEYWORDS: Building maintenance; Work at height; Emergency maintenance; Deferred maintenance; Scaffolding cost-effectiveness.

ABSTRACT

Maintenance work on building façades is a very current and widespread problem in the construction industry. Residential buildings constructed in the second half of the 20th century, with reinforced concrete frame structures, already show the first signs of physical deterioration after the first 30-40 years of life. Maintenance work, especially in southern Italy, is generally not carried out immediately, but is divided into two stages: the first stage involves making the building safe (so-called emergency maintenance) by removing unsafe parts; the second stage, sometimes years later than the first, involves completing the work by restoring the façades (so-called deferred maintenance). Often, maintenance interventions are postponed due to the excessive incidence of scaffolding, with the consequent worsening of the initial conditions of deterioration.

The study therefore aimed to develop a model for the evaluation of the most economically convenient scaffolding system, in relation to the size of the intervention and the morphological complexity of the building. In particular, the method aimed at estimating the convenience factor of the type of equipment for the maintenance works on the facades of buildings, through the development of an equation whose variables are: duration of the intervention, cost of the equipment, hourly cost of labour, no. of components of the type team. These data are cross-referenced with a corrective coefficient, Coefficient of Morphological Complexity of the building (CCM), which defines the level of accessibility of the facades for the installation of service equipment.

The results show that for urgent maintenance work, an elevating work platform is always convenient, regardless of the type of façade. For deferred maintenance work, a fixed scaffold or, where possible, a self-erecting scaffold is advantageous. As far as the cost-effectiveness of the maintenance phases is concerned, it appears that for tower buildings with a height of more than 20 metres, it will be more advantageous to carry out maintenance work as a unit. On the other hand, for a building with a height of less than 20 metres, splitting up the maintenance work involves the same costs as if the work were carried out as a unit.

CODE 176**PUBLIC BUILDINGS MAINTENANCE MANAGEMENT****Ferreira, Lélia¹; Paiva, Anabela²; Silva, J. Mendes³**

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e-mail: raimundo@dec.uc.pt**KEYWORDS:** Model; Maintenance; Buildings; Azores.**ABSTRACT**

Building maintenance is a challenge in all areas and in particular when it comes to buildings with high cultural value. It was found that the management of the maintenance of public buildings of the Regional Government of the Azores is not yet a sufficiently consolidated reality, constantly giving rise to the construction of new buildings.

The main objective of the work carried out was to develop a model for a maintenance management plan for the assets of the Regional Directorate of Culture. In this sense, an inventory of the existing heritage was carried out and maintenance plans already prepared for this heritage were analysed. These plans served as the basis for the development of a proposed maintenance plan template.

The developed model is subdivided into three submodels, A,B and C, which allow specifying and adapting them to each building. Submodel A is applied to buildings in good condition, submodel B to buildings where their use is considered to be above average or to buildings in poor condition, and submodel C to buildings with architectural specificities that require restoration. Observation sheets were used to support the survey of the state of conservation of buildings and Maintenance Technical Sheets to standardize the procedures of the maintenance cycle, facilitating the execution of maintenance.

The investigation resulted in a schematic, adaptable and easy-to-execute working document for other public and private entities that have buildings of this type under their responsibility.

This work was carried out under the Master's Degree in Building Rehabilitation at the Faculty of Science and Technology of the University of Coimbra, in collaboration with the Regional Government of the Azores, more specifically by the Regional Directorate of Culture.

CODE 352**THE REHABILITATION THROUGH EXTERNAL PRESTRESSING OF
HISTORICAL REINFORCED CONCRETE BRIDGES WITH REDUCED
PERFORMANCE: A CASE STUDY**

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KEYWORDS: Bridges; Half-joint; Gerber saddles; Riccardo Morandi; External prestressing.

ABSTRACT

Many existing reinforced concrete bridges exhibit behaviour at the Service Limit State and the Ultimate Limit State which can be considered unsatisfactory with respect to the current provisions of Codes, but which are actually deficiencies deriving from obsolete calculation methods, structure age, material degradation, diffuse or localized corrosion and increased loads. Among these, cantilever bridges with half-joints may present a decrease in global safety coefficients for the most stressed current sections of the deck or in the local ones, that affect the performance of elements sensitive to degradation, such as Gerber saddles.

In these cases, simple strengthening interventions through external prestressing that reduce the tensile stress in concrete areas subject to cracking, as well as the deformability of the points that have accumulated displacements over time (due to creep or degradation), can often be implemented without the need to recourse to interventions of greater impact, obtaining an improvement in the structural behaviour or a variation of the static scheme that improves the overall performance.

This is the case of a concrete Niagara-type cantilever bridge with half-joints, designed and built in the 60s in southern Italy by Riccardo Morandi, presented here as a case-study, which does not show a very high or widespread state of decay but rather a slight insufficiency of some elements, in particular related to the cantilever bridge behaviour. A methodology is proposed for the safety assessment of these bridges and a solution for improving performance through minimal rehabilitation interventions with the introduction of external prestressing. The results of the analysis in the present state, the deficiencies found as well as the possible level of increase in the safety coefficients at ULS with the proposed intervention are presented.

CODE 378**DIAGNOSIS OF A MODERNIST WORK: THE “PARADOR ARISTON”****Valcarce, María Beatriz¹; Vázquez, Marcela²**

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1: e-mail: mvalca@fi.mdp.edu.ar, web: www.intema.gob.ar2: e-mail: mvazquez@fi.mdp.edu.ar, web: www.intema.gob.ar**KEYWORDS:** Heritage; Rehabilitation; Corrosion; Diagnosis.**ABSTRACT**

The structure known as “Parador Ariston” is located a few kilometers from the city of Mar del Plata, on the Atlantic coast of Argentina. It stands as an example of the rich architectural heritage of the region. It was designed by the renowned modernist architect Marcel Breuer and built in 1948. It stands out for being Breuer's only work in Latin America. The structure consists of an elevated floor with curved shapes that seen from above resembles a clover. The slab is supported by four columns of the same material. Since built, it had different uses, having functioned mainly as a gastronomic and recreational space. Since 1993 it has been abandoned and neglected. The structure is located at less than 100 m from the seashore, and so the progress of corrosive processes affecting the reinforcing steel of reinforced concrete should be evaluated. Corrosion in reinforced concrete compromises the integrity of a structure and the safety of people circulating nearby. Cracking and delamination of concrete and reductions of diameter of the reinforcements. It also affects the environment of the structure since detachments of material can occur are often observed. Structural compromise can be established by carrying out an in-depth diagnosis of the structure. The evaluation was carried out trying to minimize destructive interventions. A visual survey was undertaken, including measurements of corrosion potential, degree of carbonation, cover thickness and diameter of reinforcements. The inspection showed no indications of corrosion processes endangering the integrity of the structure. Some sectors were identified where immediate attention was required to delay deterioration. Preventive measures and repairs were recommended. This study is expected to contribute to expanding the city's heritage, recovering an emblematic building so that it can be visited and appreciated by locals and tourists.

CODE 388**REMOTE INSPECTION OF THE INTERIOR OF CHANNELS AND STORAGE TANKS OF THE WATER SUPPLY AND SANITATION NETWORK**

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KEYWORDS: Drone; 3D mapping; Autonomous navigation; Water; Inspection.

ABSTRACT

As water supply and sanitation networks age, the risk of deterioration, blockages and collapses increases. Periodic inspections of these networks are essential to know the state of conservation and optimize the planning of maintenance operations.

Nowadays, inspection work is mainly carried out by professional operators who must work in confined spaces, in extreme conditions of temperature and humidity, and in the presence of a large amount of waste and volatile substances.

As a new alternative, a system has been developed for the remote inspection of the interior of channels and storage tanks of the water supply and sanitation network. The system is based on three main components/phases:

- **IN-SITU SCANNING:** Use of unmanned aerial vehicles (drones) for scanning the interior of the infrastructure.
- **REMOTE INSPECTION IN DIGITAL ENVIRONMENT:** Generation of digital models with the captured information (3D point clouds and high resolution geo-positioned images) on which to detect and record the deterioration.
- **EVALUATION AND ISSUANCE OF RECOMMENDATIONS IN DIGITAL ENVIRONMENT:** Automation of the issuance of conservation indices and repair recommendations based on the registered deterioration.

The developments have been executed within the framework of a collaborative project between the companies Hovering Solutions, IDP and Tecnalia technology center, with funding from the RIMA Network (Robotics for Inspection and Maintenance) of the European Commission.

CODE 15**MANUAL OF GOOD PRACTICES IN THE TRADITIONAL RURAL
ARCHITECTURE OF GRAN CANARIA: THE DWELLING-CAVE**

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KEYWORDS: Manual; Traditional rural architecture; Gran canaria; Patrimonial value; Dwelling-cave.

ABSTRACT

This communication is about the process of preparing a Manual of Good Practices, born from the need of the Servicio de Patrimonio Histórico of Cabildo de Gran Canaria, Canary Islands, to respond to a high number of requests received for the intervention and rehabilitation in properties with heritage value in rural areas.

The main objective of this manual is to identify and systematize the heritage values of said properties to propose a set of technical criteria for intervention in rehabilitation, conservation and restoration actions of buildings of ethnographic value (popular rural architecture), mainly located on lands classified as suelo rustico, for a better conservation of the attributes of value and at the same time to generate the conditions for an adequate habitability and use of these constructions.

The methodology used in the elaboration of this work is based on the observation, study and classification of a selection of representative buildings of the traditional rural architecture of Gran Canaria, taking as reference the intervention and rehabilitation requests that come to the local administration. One of the principles of the field work has been to detect the recognized values of traditional constructions, starting from the premise that "patrimonial value resides in the details, and its the join of all that form the value of the building."

The approach to work from various disciplines has also been a methodological vector that, with a transversal approach, add contributions and resources for analysis and interpretation of the object of study and of the propositional part of the edition: architecture, historiography, human geography, anthropology and archeology.

On the island of Gran Canaria, two parallel forms of habitat have developed throughout its occupation: the excavated house and the build house, that's why the manual is divided in two large blocks: construction of masonry houses in stone bearing walls, and the dwelling cave, being the dwelling cave section the one that we will present in the article.

CODE 36**PREVENTIVE MAINTENANCE OF EXISTING BUILDINGS USING BIM TECHNOLOGY FOR THE OPTIMISATION OF RETROFITTING PROCESSES****Sagarna, Maialen^{1*}; Otaduy, Juan Pedro²; Mora, Fernando³; Leon, Iñigo⁴**

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e-mail: inigo.leon@ehu.eus, web: <http://www.ehu.eus>**KEYWORDS:** Preventive maintenance; BIM; Process optimisation; Rehabilitation.**ABSTRACT**

BIM technology yields benefits in operation and maintenance management. The largest costs are not incurred in the design or execution process, but in the use phase of the building, concentrating on the operation and maintenance tasks required throughout the life of the asset. The key to extending the service life of existing buildings is implementing a proper preventive maintenance strategy to anticipate issues or failures, enabling the right decisions to be made in advance.

The research project entitled "BIM technology for the optimisation of cultural and architectural heritage management" has analysed how a BIM model can be used to plan the preventive maintenance strategy of a recently constructed ventilated façade of a Building located in San Sebastian. To this end, a specific set of properties has been defined as well as the periodicity of revisions to be applied to the different parts that make up the ventilated façade. On the other hand, useful Information such as the use and maintenance manual or the technical data sheet of the panels has been linked to the model as an aid for maintenance tasks. The implementation of this information in a three-dimensional model has shown that using data sheets and identifying each single element in the digital model, enables defining the appropriate preventive maintenance to improve the refurbishment processes.

CODE 50**PRESERVING THE 20TH CENTURY INDUSTRIALIZED BUILDING HERITAGE
IN ITALY: COMBINING HISTORICAL SURVEYS AND PHILOLOGICAL BIM****Mornati, Stefania; Giannetti, Ilaria**

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e-mail: mornati@uniroma2.ite-mail: giannetti@uniroma2.it**KEYWORDS:** HBIM; Philological modelling; Construction history; Industrialized building heritage; Italy.**ABSTRACT**

In 20th Century Italy, building industrialization was a weaker process than in other European countries. Nevertheless, the experimental buildings of the second half of the century feature innovative construction solutions. Nowadays, these works represent a fragile in-use building heritage that, still neglected by the recent historiography of architecture and construction, demands urgent maintenance interventions, based on accurate knowledge of the time technologies. In this context, this contribution focuses on the role of historical analysis-based BIM modeling for cultural exploitation and maintenance programming. Extending the scope of the current Scan to BIM methods, applied to historical buildings, this paper discusses a philological modeling approach, exploiting archival materials produced by the building process. In particular, the work presents a historical documents-based BIM, supporting the cultural exploitation and maintenance planning via quantitative data. The case study of the philological BIM of the former maternal school building (1971-75) in Latina municipality in Italy, designed by architect Luigi Pellegrin (1925-2001), is deepened. A cross-referenced investigation of several primary sources -the Pellegrin Archive preserved by the CSAC (Parma), the Archive of the former School Building Department of the Italian Ministry of Education, and the Archive of the Italian Patent Office-, completed by on-site survey, supports the philological BIM approach.

CODE 86**MICROCLIMATE FOR PRESERVATION IN A LIBRARY: ASSESSMENT OF TEMPERATURE AND RELATIVE HUMIDITY PRE AND POST CONFINEMENT****Diulio, María de la Paz¹; Gómez, Analía Fernanda²**

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KEYWORDS: Library; Environmental monitoring; Preventive conservation; Pandemic; Internal loads.

ABSTRACT

Temperature and relative humidity are two properties of the air that affect preservation: its lack or excess can accelerate the deterioration of organic materials like, for example, books in a library. Also, the internal loads derived from the occupation of the buildings constitute sources of heat and water vapour that modify these variables. During 2020, the lockdown established for limit the COVID 19 pandemic kept users and staff away from the University, while changes in the air mixture around the collections of the Library of the Faculty of Architecture and Urbanism have been observed. This paper shows the analysis of hygrothermal monitoring data carried out before and during confinement to quantify the effect of internal loads in a university library, and thus evaluate its impact on preservation. The most significant difference observed is the limitation of daily fluctuations, which influence the mechanical deterioration of organic materials, concluding that in this aspect, the absence of personnel due to confinement represents an advantage for the conservation of collections.

CODE 92**APPLICATION OF A FUZZY LOGIC SYSTEM WITH EMPHASIS ON CLIMATE CONDITIONS IN THE BUILDING SECTOR IN CHILE****Carpio, Manuel^{1, 2}; Prieto, Andrés J.³**

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KEYWORDS: Fuzzy logic system; Building; Climatic conditions; Decision-making; Chile.

The climatic changes of the last decades are becoming more and more visible in large parts of the main urban centres. Buildings are not exempt from the passage of time, and even more so when external environmental agents affect them directly. To preserve buildings and extend their life cycle, it is necessary to use applications that facilitate decision-making when generating and proposing preventive maintenance programs versus corrective maintenance actions, which are usually very expensive and challenging to finance. Currently, the construction sector is undergoing a critical digitalisation process, which includes different technologies in search of developing the area and making its activities more efficient and less expensive in the face of the new challenges of today's society. In this sense, artificial intelligence and, therefore, fuzzy logic systems, validated by experts in the area, help carry out this task objectively and optimise time and resources. Recently a new fuzzy logic method has been created, which allows a systematic classification of the behaviour of buildings and their performance based on climatic conditions. In the South American context, Chile is one of the significant economic engines of the region. The country has a multitude of residential buildings classified as of particular interest. Chile's climatic conditions are diverse and with significant intraday and intraannual fluctuations. These conditions mean that particular emphasis should be given to the effect on buildings of the main climatic variables such as temperature, relative humidity, rainfall, wind and solar radiation. For all the above, the main objective is to analyse the application of a fuzzy logic system, emphasising climatic conditions in the construction field in a study area with many climates to observe its behaviour. This study may generate new advances regarding the influence of climatic indicators on the functional behaviour of residential buildings located in South America.

CODE 136

ANALYSIS OF ANTHROPIC AND SOCIAL THREATS OF THE ARAB WALL OF ALZIRA

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KEYWORDS: Earthen Architecture; Social vulnerability; Anthropic risks; Moorish walls; Alzira.

ABSTRACT

This study is focused on the evaluation of the non-natural hazards of the Moorish wall of the city of Alzira (Valencia, Spain) founded by the Arabs with the name of "Al-Yazirat Suquar" (Xúquer's island) due to its location on a meander of the river Xuquer. The Moorish wall that surrounded the river island is the most relevant construction of this period, combining the defensive function together with the protection against recurrent floods. Built, almost entirely, using the rammed earth technique combined with adobe and stone masonry, it was listed and declared Asset of Local Relevance. At the end of the 19th century and the beginning of the 20th, because of the expansion needs of the city, the more than 2 km long wall was demolished, being preserved, nowadays, less than a third of the original length.

In order to establish different intervention strategies and increase the resilience of the archaeological and monumental remains, a comprehensive study of natural, anthropic and social risks is needed. Having analysed the former within the Risk-Terra research project [1], this study focusses on the anthropic threats taking as starting point the documentation of the interventions carried out to retrofit and recover the Alzira's wall and the analysis of the city council provisions related to the area of influence.

To evaluate the social opinion, the results of the surveys of the public participation plan carried out for the study of landscape integration for the Special Protection Plan of La Vila de Alzira are analysed and completed with the anonymous responses of a survey specifically designed for this case study.

Finally, a series of recommendations to reduce the anthropic threats are proposed, together with the design of an information campaign and dissemination of the values of this Asset of Cultural Interest, among the Alzira's citizens and society.

CODE 138**SLOPE STABILIZATION BY ROAD ROTATIONAL SLIDE IN
THE JUNGLE OF PERU**

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KEYWORDS: Slope stabilization; Rotational landslide; Topographic; Geological-geotechnical and hydrological studies; Swedish Method.

ABSTRACT

This research was developed in the Faculty of Civil Engineering and Architecture, National University of San Martín - Tarapoto, for professional qualification, as a contribution to knowledge and society, to solve the problem of Rotational Landslide of the 300 m settled section of the Ruta Departamental Highway. SM-106 Section Junction PE-5N (Colombia Bridge) – Shapaja – Chazuta, located in the San Martín region.

The contribution consists of a Proposal for the Stabilization of the Slope of the indicated section, due to the poor condition of the road, solving the problem and protecting the road assets, since it improves traffic and communication, facilitates the transfer of vehicles and agricultural production of the localities. beneficiaries and towns of Bajo Huallaga to consumer markets and generating a scientific asset for our University.

The methodology followed allowed for in-depth studies on the local and global stability of the slope that runs parallel to the road; For static conditions, analyzes were carried out that estimated the behavior of the slope (local faults), whose instability generates serious danger and possible human and material losses. The analysis and engineering design and the budget of a solution to stabilize, under the minimum static conditions of the slope, in a section of 300 meters in length of the road for the design of the proposal are developed.

It was shown that the section under study would fail under the studied static conditions, putting road users in serious danger, so slope stabilization solutions are proposed, which includes massive earthworks, reducing the slope, increasing the Safety Factor. for global stability and the construction of sidewalks or terraces that will stabilize the slope due to rotational sliding. This engineering work provides cost ratios; deducted directly from the budget, as a useful tool for making decisions by the corresponding authority that has to do so.

CODE 151

CHARACTERISTICS OF THE CULTURAL HERITAGE PREVENTIVE CONSERVATION SYSTEM OF SOUTH KOREA

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KEYWORDS: Heritage management; Sustainable conservation; Preventive conservation; Heritage Care Program.

ABSTRACT

Heritage Care Program (HCP), which started as a permanent management project for the cultural heritage in South Korea in 2010, has been the representative preventive conservation system in the field of preservation of cultural heritage in South Korea by not only continuously managing cultural heritage but also promptly responding to crisis situations of it for more than 10 years.

In 2010, 91 workers underwent minor repairs and daily management for 691 cultural heritages. Gradually, the scale of manpower and cultural heritages was increased and the task of regular monitoring of cultural asset was added. After all, 691 workers were managing 8,665 cultural heritage in 2021. The budget supported by the country has also increased 30 times from \$161,738 in 2010 to \$27,293,064 in 2021.

As can be seen from the above, the processes in which the HCP is established as a preventive conservation system in South Korea is different from the European preventive conservation management models of MWN, MWV, and Bath Area Pilot. For example, while the European preventive management system is an assistant for the maintenance activities of the owners of cultural heritages, the HCP is a national public project regardless of whether the owner of the cultural heritage exists or not.

This study intends to analyze the characteristics of the HCP through comparison with the European cultural heritage prevention management model.

CODE 238**SAN JUAN DE GAZTELUGATXE, HOW TO MANAGE THE RESILIENCE OF A
UNIQUE LOCATION ON THE COAST OF THE BASQUE COUNTRY**

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KEYWORDS: Resilience; Hermitage; Conservation; Maintenance; Tourism; Emergency.

ABSTRACT

San Juan de Gaztelugatxe is a special location where land, sea and people come together. It is a space of outstanding heritage, cultural and environmental level but which in turn is fragile and must be protected; and more in recent years, where visitors have increased enormously. In this challenge of protection and conservation of the location, a series of studies and repair and rehabilitation works have been carried out since 2017 from an integration perspective that respond to the complexity of the place. The intervention in the access road to San Juan de Gaztelugatxe is a complex task in which it is necessary to manage and integrate, in addition to the execution of the work itself, the compatibility with the flow of visits by people, the adverse climatic conditions and the natural context itself conditioned by the scourge of the sea, the complex access to the intervention points, and to the economic limitations that condition the prioritizations and scope of the interventions.

This article shows what is the route designed for intervention in some elements of the road and in some points of the natural terrain, to avoid the risk of suffering problems in the medium term that involve interrupting visits to the location and the economic and social disorder that this entails.

It is clear that the interventions to be carried out will in no case solve the problem in its entirety, but that they are intended to slow down the process of deterioration, since the severity of the external agents that affect the location can not be controlled or predicted and consequently can not be acted on.

But these circumstances have allowed the agents in charge of its management to plan the interventions in this special location, focusing them towards a new paradigm of preventive and predictive maintenance oriented to the resilience.

CODE 357**THE CONTRIBUTION OF DESCONSTRUCTION TO
THE PRESERVATION OF PORTUGUESE OLD BUILDINGS****Ranna, Gabriela¹; Torres, Isabel²; Silva, José³**

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e-mail: raimundo@dec.uc.pt**KEYWORDS:** Deconstruction; Preservation; Ancient Buildings.**ABSTRACT**

The Portuguese building stock is inserted in a life cycle of extraction-use-disposal, corresponding to the phases of "production stage", "use" and "end of life" [1]. In the specific case of Portugal, the building stock has the particularity of having more than 500 thousand buildings built before 1946, that is, before the adoption of reinforced concrete as the predominant construction technique [2].

"Deconstruction" is the process through which buildings are systematically dismantled, often manually or using basic tools, in order to preserve the maximum intrinsic values of the recovered materials [3]. This work aims to contribute to the adoption of deconstruction as a viable option for the end of life of old buildings in Portugal, to help to preserve the intrinsic, social, and historic value of ancient components and materials.

Through the analysis of the deconstruction capacity and the evaluation of the intrinsic, social, and historical value of the components and materials recovered through the deconstruction of old buildings at the end of their lives, this research seeks to encourage the reintroduction of such components and materials in the production cycle.

The methodology and tools presented in this work are applied to old Portuguese buildings, however, they are shown to be applicable to any other type of building that is a candidate for deconstruction.

The application of the proposed methodology and tools in Portuguese old buildings showed that such buildings have many constructions attributes related to the design for deconstruction and that they are good candidates for the recovery of elements and materials, and that it is possible to preserve the intrinsic, social and historical values of such recovered elements and materials, and it is economically viable to reintroduce them to the production cycle.

5.- DIFFUSION AND PROMOTION

5.1.- HERITAGE AND CULTURAL TOURISM.

5.2.- TEACHING AND TRAINING.

**5.3.- NEW TECHNOLOGIES APPLIED TO THE HERITAGE
DIFFUSION.**

5.4.- ACCESSIBILITY TO CULTURAL HERITAGE.

5.5.- BUILT HERITAGE MANAGEMENT.



CODE 35**DISUSED RAILWAY STATIONS AND BUILDING AND ENVIRONMENTAL
RECOVERY STRATEGIES****Radogna, Donatella**

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KEYWORDS: Sustainable development; Reuse; Railway; Small towns; Slow tourism; Anthropization and nature.

ABSTRACT

Disused railway stations are resources having many values, given by the distribution of the buildings on the territory and by the relationships that they can create to "put into operation" the resilience capacities of places. These aspects intercept the guidelines for the ecological transition and the social and territorial inclusion of the European Community and the Italian PNRR which provides for investments in the beauty of the country for the enhancement of the protection of the artistic, cultural and natural heritage and the consolidation of usability and tourist attraction capacity.

For several years, Italy has encouraged initiatives of this type such as the "Valore Paese Italia" projects aimed at rediscovering sustainable tourism, culture, the environment and agriculture through the enhancement of disused public buildings.

About four hundred and fifty abandoned stations were converted to enhance the territory and provide services to citizens and about four hundred and sixty-five kilometers of tracks became tourist lines, cycle paths and greenways. In this scenario, research work was developed on disused stations, distributed along the Costa dei Trabocchi, that is along the stretch of the former Adriatic railway of the Province of Chieti, now an important cycle path and seaside destination. This reality is an important node for putting local resources in synergy, creating transversal and parallel to the coast connections (relating the sea to internal areas and transferring mobility from cars to boats, bikes and walks) connecting small towns with the train and offering services for land and sea sports, culture and typical products.

Considering the main activities affecting the area (seaside, bike and food and wine tourism), the research aims to minimize their impact on the environment. No new constructions are foreseen and concentrated services are proposed in the recovered stations (bicycle rental and equipment for water sports, refreshment points, toilets, infirmaries, cycle-workshops, etc.) which become the place of distribution even for ephemeral minimal and totally removable systems (mainly shaded spots and bathing furniture). In this way, building and environmental rehabilitation strategies are proposed and the reuse of pre-existing buildings favors the sustainable development of the territory.

CODE 47**INDUSTRIAL HERITAGE IN THE PROVINCE OF ALMERÍA.
ANALYSIS AND REUSE FOR A SUSTAINABLE TOURISM****García-Ruiz, Almudena¹; García-Ruiz, Luisa-María²; Sáez-Pérez, María-Paz³**

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KEYWORDS: Industrial heritage; Province of Almeria; Sustainable tourism; Architectonic rehabilitation; Urban regeneration.

ABSTRACT

Several studies highlight the renovation of industrial historical places compose a useful tool to support urban renovation, attracting to new residents, creative sector companies, as well as promote the tourism development. Recovering of this industrial heritage is linked to cultural, economic, social, environmental sustainability, despite specific conflict of interest created because of this historic legacy. Consequently, helping in the evolution of the touristic sector must imply the preservation of the industrial architecture by the development of an activity capable of the reactivation of obsolete industrial spaces, unused and without the necessary maintenance during its history.

This research about Industrial Heritage in Almeria, as well as the followed methodology applied in 412 elements which belong to the industrial activity of the 19th, allows knowing the possibilities of the recovery.

Classification of the buildings according to used raw materials: Agroindustry, craftworks, hydraulics, mining, fishing, and salt mine; and the done analysis let knowing the existing situation in every region in the province of Almeria. It is observed that these buildings are spread in the territory in a different way. Therefore, rehabilitation plans developed by regions and intervention proposals in specific buildings according to influence and location. Taking into account some aspects previously studied, for example, construction state, conservation and chronology. Finally, the recovery proposal of heritage buildings considers new uses related to touristic development.

Touristic in-use of these industrial buildings highlight their value and supported its maintenance, avoiding their loose, recognized by their current abandoned state. Besides, sustainable touristic activity will bring an economic, urban and social improvement in Almeria.

CODE 49**EVOLUTIONARY, MORPHOLOGICAL AND ACOUSTIC ANALYSIS OF
CLASSICAL GREEK THEATRES. PARAMETERS FOR PRE-DIMENSIONING
AND REHABILITATION****Mesto, Suleiman; Rubio, María Jesús**

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e-mail: mariajesus.rubio@upm.es, web: <http://www.upm.es/>**KEYWORDS:** Reflection Surface; Refurbishment; Sound; First Reflection; Reflected Listening Angle.**ABSTRACT**

This article aims to analyse the evolution of Greek theatres from their origin to the period of greatest splendour, the Classical Period (V century B.C.- IV century B.C.), collecting the different acoustic and morphological factors from celebrities such as Vitrubio (I century B.C.) from the Roman period, or François Canac, a French engineer from the XX century A.C. Recent studies on sound propagation and early reflections in Greek theatres should not be forgotten.

Once the optimal ranges of the dimensions of the scenographic and location elements have been established, these will allow the realization either of a pre-dimensioning of a "new" theatre with a classical aspect, or the necessary parameters to be able to rehabilitate in an efficient way the constructions that have arrived from Classical Greece up to our days, in order to be able to fulfill the main objective that these interpretation centres have, the reception of the word in a legible way by all the public.

CODE 87**AN EXAMPLE OF THE ANALYSIS OF RURAL SETTLEMENTS:
ASAGI BELEMEDIK VILLAGE****Ortakaya, Esra Nur^{1*}; Umar, Nur²**

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e-mail: numar@atu.edu.tr, web: <https://adanabtu.academia.edu/NurUmar>**KEYWORDS:** Aşağı Belededik; Rural heritage; Conservation; Heritage management; Cultural tourism.**ABSTRACT**

Aşağı Belededik is a historic village located in southern Turkey and depending on Karaisalı which is a district of Adana province. The village has importance in terms of its ancient history and having unique examples of traditional stone houses. Aşağı Belededik is among the rare villages that have preserved its originality in the Karaisalı region. Another distinctive characteristic of Aşağı Belededik-which has an effective role in choosing this village as a case study- is being close to touristic areas. Aşağı Belededik village which is called “Keşiştepe” in old times, settled on a rocky area. Because of easily found in nature, being reachable and cheap; stone has become the main material used in the construction of houses. The craftsmen who built these stone houses are not alive today so this traditional construction technique has documentary value. Rural heritage, which is an important part of local culture, is under threat due to factors such as abandonment or unconscious renovation of buildings. Besides tangible heritage, intangible heritage is also affected from these factors. Being vulnerable to today’s conditions makes it necessary to work on the conservation and sustainability of the rural architectural heritage. To understand the current state and the potentials of the Aşağı Belededik analyzes at the scale of settlement and building will be made through on-site observation and photographing methods. In addition, the survey method used and interviews to inhabitants made to determine the social, economic, and physical situation in the village. Inventory slips will be prepared for each stone house which has a unique characteristic. The scope of this research is to develop cultural tourism activities through planning a cultural route in the Karaisalı district to protect cultural and natural heritage. Therefore, a cultural route is planned which includes Aşağı Belededik village and touristic areas around it. In conclusion, the tangible and intangible values of the rural heritage must be preserved as a whole. Also, appropriate heritage management methods should be developed in the conservation process involving local people.

CODE 109**PROPOSAL FOR INTERVENTION IN ABANDONED ARCHITECTURE: THE
ROMAN TEMPLE OF VIÑEROS IN THE CITY OF MÉRIDA****Agudo Martínez, Andrés^{1*}; Fernández Castelló, Francisco²; Vázquez Sánchez, Gloria³**

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e-mail: glovazsan@alum.us.es**KEYWORDS:** Temple; Roman challenges; Heritage; Cultural tourism.**ABSTRACT**

In 2007, a developer acquired a plot of land in the centre of the city of Mérida (Spain), and taking as a premise the compliance with the urban planning regulations, the protocol of the city and the criteria of the Consorcio de la Ciudad Monumental Histórico-Artística y Arqueológica de Mérida, the company commissioned a project for the construction of a new four-storey building, articulated around a circular courtyard located towards the back of the plot.

Prior to the start of the works, an archaeological protection campaign was carried out, which included the demolition of the remains of an old dwelling dating from the first half of the 20th century, the removal of rubble and weeds and the unearthing of Roman remains. During the excavations, the Roman Temple of Viñeros was uncovered.

Despite its repercussions on the conception of the Roman Forum of ancient Emerita Augusta, fourteen years after the discovery, the Temple is abandoned and neglected due to the lack of adequate patronage. It is our intention to promote a strategy based on sustainability, the optimisation of resources and accessibility, which minimises the deterioration of the building and leads to its conservation, in order to promote the approach of a cultural asset to society. To this end, we base our proposal on the reconstruction of the building by means of an architectural prosthesis, which will allow the dissemination, promotion and enjoyment of the Temple, as well as the cultural, welfare and social purposes of this architectural heritage.

CODE 188**ADVANTAGES OF FLIP TEACHING ACTIVE METHODOLOGY DURING
THE COVID-19 PANDEMIC**

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KEYWORDS: Flip Teaching; Flipped Classroom; Inverted Classroom; Collaborative work; ICT.

ABSTRACT

The 2019-2020 academic year will be remembered as the stage when teachers had to adapt the teaching-learning process used so far, fundamentally face-to-face teaching, to the new environment that the COVID-19 pandemic had subjected us to. It has been a year when decisions had to be made "on the go", in order to, basically, move from face-to-face classes to online learning. Those who initially thought it would be enough to teach face-to-face lessons through a webcam, soon realized that - even though two screens were in use, one for the notes the teacher might need to teach through the webcam, and the second to detect the degree the students were following the class - the idea was not the best. The use of active methodologies, which a small number of teachers had been using, allowed us to face with dignity the new environment created by the aforementioned pandemic, which is still with us. In these pandemic times we are living, of all the different existing active methodologies, we have been able to notice an acceleration in the use of the Flip Teaching methodology, also known as Flipped Classroom or Inverted Classroom. This approach has changed the basic teaching sequence, because students receive lectures at home and perform tasks in the classroom. In this paper, we present the advantages observed in the mentioned academic year, when using active Flip Teaching methodology.

CODE 12**INVENTORIES FOR THE PRESERVATION AND DISSEMINATION
OF THE ARCHITECTURAL HERITAGE****Quintilla, Marta; Agustín, Luis**

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KEYWORDS: Cultural heritage; Inventories; WebGL; Viewers; 3D model.**ABSTRACT**

The preservation of the cultural values of the architectural heritage must be properly safeguarded, by registering the volumetric information and all the complementary information associated with the property. In this way, thanks to a correct graphic documentation, its investigation, conservation and dissemination is ensured.

The purpose of the communication is to show the evolution of cataloguing methods, and how new technologies have helped its development, necessary for the preservation and dissemination of the Architectural Heritage. We want to present some of the latest technologies that allow the visualization of 3D models through web platforms or mobile applications thanks to the incorporation of the WebGL standard, which eliminates the need to use additional plugins or extensions. These platforms are capable of displaying high resolution point clouds or meshes that facilitate the dissemination of heritage thanks to their simplicity and ease of use.

The Church of San Félix in Torralba de Ribota, belonging to the Aragonese Mudejar style, declared a World Heritage Site by Unesco, will be documented in order to expose the work methodology to create a graphic database that contains the information necessary to document the Mudejar architectural heritage of Aragon and thus allow the dissemination of knowledge, and its use for research, but also for popular dissemination and mass consumption.

CODE 27**THE GEOMETRIC APPEARANCE OF COLUMNS AND FRAMES IN THE
PALATIAL OTTOMAN ARCHITECTURE OF THE ALGIERS CASBAH: WHAT
PROCESS TO CREATE?****Aïcha, Bibimoune¹; Samia, Chergui²**

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KEYWORDS: Architectural ornament; Algiers; Ottoman palaces; Columns and frames; Geometric patterns.

ABSTRACT

In order to highlight the architectural ornaments of marble and limestone in Casbah's Ottoman palaces at Algiers, as an architectonic heritage, the present contribution aims first to recognize several types of geometric patterns that manifest on columns, door and window frames. Then, it aims to demonstrate how these ornaments were created, and what was the source of inspiration to their creators. To this end, we use a combination of a field investigation and digital restitution, meanwhile with bibliographic review, applying on the most authentic geometrical motifs of selected Ottoman palaces that situated in the lower Casbah of Algiers. As results to this paper, it appears that the famous rules of perfection in ornamentation exist in these geometric ornaments, at the base of a geometric outline. In addition, it seems that Moorish, Turkish, Renaissance, and more other arts had an impact on the ornamental design of this architecture. Through all this, it will be possible to achieve a detailed corpus of the most interesting patterns of these luxurious objects.

CODE 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)**

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KEYWORDS: Survey; Digital photogrammetry; Inclusive museum; 3D reconstruction.

ABSTRACT

Precise graphical surveying of an archaeological site is always necessary to perfectly document excavated structures. But when it is known that the site will be covered by a new building that will prevent it from being accessible and / or visible, this graphic analysis becomes an obligation, as it will be the only guarantee of being able to continue analyzing and investigating it. This is what has happened at the Hoya de los Molinos Archaeological Site, in Caravaca de la Cruz (Murcia Region, Spain), where archaeological evidence of a vertical hydraulic mill from Roman times has been documented, something exceptional in the Iberian Peninsula. For this reason, it was considered essential to carry out the three-dimensional model of the deposit by means of a survey with a 3D laser scanner, terrestrial photogrammetry and classical topography, so that the researchers could continue working, with precise models, once the deposit had been covered. The historical-constructive study carried out on this type of Roman mills and the analysis of the archaeological evidence found, have made it possible to carry out a virtual reconstruction of the site and the hydraulic mill. An explanatory video of the site and five models have been made, with a 3D printer, from the three-dimensional models measured and the virtual reconstructions made. The first model shows the site as a whole, while the others detail the area of the hydraulic mill, as it was in the excavation, with the vertical hydraulic wheel and the reconstruction of the gears and mechanisms for grinding the grain. And finally the last with the building that protected and housed them. These scale models make it possible to show and identify all the elements that, according to the analyzes carried out, made up the whole of the mill. Finally, the models and video will be located in an exhibition space of the Municipal Archaeological Museum of La Soledad, in Caravaca de la Cruz, for their inclusive dissemination, thus contributing to the knowledge, musealization and dissemination of this important archaeological find.

CODE 113**3D MODELING AS A VALIDATION SYSTEM FOR THE RECONSTRUCTION OF
THE DISAPPEARED HISTORICAL ARCHITECTURAL HERITAGE:
THE OCTOGON OF VALLADOLID**

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KEYWORDS: Architectural heritage; Prison; Panopticon; Military college; Model 3D.

ABSTRACT

Technological progress in virtual tools and techniques for three-dimensional modelling deployed in the last decade offers potential advantages for the reconstruction and interpretation of disappeared architectural heritage, as a step on knowledge, study and documentation, previous to 4D digitalization. The searching phase, aimed to obtain information in order to create a virtual representation of a historic building must be precise and accurate. Reachable sources are not always fully reliable, as they can offer partial data or because they are assigned for purposes differing from architectural ones, so that it is necessary to test their reliability for the work subject.

In this research, we analyze the digital model created for reconstruct the volume of the prison known as “Octagon”, on which only remains descriptions and fragmentary graphic documents of later uses, being its initial nature modified. A modelical building with a radial octogonal plan, built in Valladolid in the 19th century, derived from the penitentiary theories of the time and earlier, such as the panopticon of J. Bentham, and with a short period of use as prison. The complex, destroyed after a fire when used as Military College, was completely affected, leading to the construction of the current Cavalry Academy some years later.

With the reconstructive virtual modelling of this architectural example, we test the suitability of the research paths and their documentation, interpretation and representation sources. In this prison, we analyze the reliability of the data for academic purposes and the visualization of historic scenarios with graphical means, without forgetting its utility as a tool for knowledge transfer, diffusion and transmission of interest in heritage that, even disappeared, has given shape and character to our cities.

CODE 286**MIXED VIRTUAL TOUR FOR THE DISSEMINATION OF THE
DECONTEXTUALIZED HERITAGE. THE OVIEDO CATHEDRAL CHOIR
STALLS****Sánchez Riera, Alberto; Pàmies, Carles; Navarro, Isidro**

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KEYWORDS: Mixed reality; Decontextualized heritage; Oviedo cathedral stalls; Virtual tour.

ABSTRACT

The dismantling of different chairs of Spanish cathedrals and monasteries to different places for which they were conceived, is a clear example of decontextualization of the architectural heritage. This work explains the virtual reconstruction process of these structures, many times partially preserved, as well as the methodology for their geometric integration in equirectangular photographs taken from their original locations. Initially, the fully preserved stalls of the Yuste and Nájera monasteries have been modelled using photogrammetry and three-dimensional modelling techniques. Based on these previous experiences, a decontextualized case study is proposed in the Oviedo Cathedral. Its gothic choir has been virtually completely reconstructed from its relocated remains still preserved. The resulting 3d model has been geometrically integrated in equirectangular images taken from the original site. To do this, we have started from the scarce existing historical documentation on its original configuration and from the geometric and material information of the rest of the preserved elements. To its visualization the model has been integrated into an application that offers to the users, in an interactive and immersive way, a “mixed” virtual tour of the central nave of the cathedral that incorporates the virtual model in its original location. The methodology used supposes a new combination of mixed reality techniques that, in an economic, interactive, ubiquitous, and universal way, must allow progress in the dissemination of decontextualized heritage.

CODE 291**DEFENSIVE ARCHITECTURE, DIFFUSION AND NEW TECHNOLOGIES.
ANALYSIS OF THE NATIONAL PARK SERVICE AND PARKS CANADA
STRATEGIES****Mira Rico, Juan A.¹**

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KEYWORDS: National Park Service; Parks Canada; Defensive architecture; Diffusion; New technologies.

ABSTRACT

The National Park Service (United States of America) and Parks Canada are two government offices that preserve cultural and natural values for the enjoyment, education and inspiration of future generations (National Park Service), and promote the public understanding, appreciation and enjoyment of relevant examples on cultural heritage in order to ensure their preservation for future generations (Parks Canada).

Therefore, they have become interesting models of analysis in different fields such as heritage diffusion. In this sense, this study is aimed to know how both offices work on the diffusion of defensive architecture using new technologies. For that purpose, a descriptive and morphological analysis, a content analysis and a functional analysis from the user's point of view have been carried out on Castillo de San Marcos (United States of America) and Fortress of Louisbourg (Canada) applications according to the qualitative methodology. These are two significant examples of defensive architecture managed by the National Park Service and Parks Canada. Likewise, some similarities and differences have been found on these applications, which has made possible to study their use in other countries like Spain.

CODE 304

**MALAKA.NET AS A COMPREHENSIVE WEBGIS PLATFORM TO MANAGE
CULTURAL HERITAGE. A COMPARATIVE CASE STUDIES**

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KEYWORDS: Cultural heritage; GIS; Management heritage; Digital inventory.

ABSTRACT

The city of Malaga has a wide range of heritage assets which have been declared on the basis of different protection policies. However, their lack of transversality has led to the non-existence of a comprehensive database. This research aims to inventory, locate, and assist heritage in order to put together the different sources on a single platform as the main contribution: Malaka.net. To do this, the Arches web model is presented as an open-source content management system. It has been adapted to generate a comprehensive inventory categorising heritage into several topics: Architecture, Archaeology, Landscape, Urban Furniture and Intangible heritage. All of them are included in official lists and catalogues for the protection by different administrations. Thus, an intuitive webGIS platform has been developed to offer an open access holistic database which is fed by different local stakeholders. This collaborative management of the platform aims to promote citizen participation to put in value tangible and intangible cultural heritage. One of the contributions of the platform is the incorporation of a heritage conservation assessment which allows updating the rehabilitation values architectural and landscape assets. Another innovation is the visualisation of the relationships between the different heritage categories based on their geolocation by layers. Mapping, cataloguing, and management allow establishing a comprehensive understanding about heritage not only on a local scale, but also on a territorial one; what serves as basis for the administrations to define future intervention policies.

CODE 312

**A COMPARATIVE STUDY BETWEEN A STATIC AND A MOBILE LASER
SCANNER FOR THE DIGITALIZATION OF INNER SPACES IN HISTORICA
CONSTRUCTIONS**

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KEYWORDS: Cultural heritage; 3D digitalization; Laser scanning; Wearable mobile laser system.

ABSTRACT

The interest on multidisciplinary and scientific approaches for the management of valorisation and conservation of cultural heritage sites has notably increased in the last decades following the international guidelines. Within these approaches, the use of techniques such as photogrammetry and laser scanning appear as a reference for the generation of 3D models and HBIM models. More recently, wearable mobile laser systems arose as an alternative to traditional laser scanning allowing reduced fieldwork times and minimized error propagation in complex scenarios. This paper presents a comparative studio between the static laser scanner Faro Focus 120 and the wearable mobile laser system ZEB-Revo. The latter is based on the use of the SLAM (Simultaneous Location and Mapping) approach for generating the 3D point clouds, reducing the time required in-field in about 10 times but presenting some limitations such as the possible error accumulation (non-linear deformation) among others. According to this, this works will evaluate both sensors at different levels: from the data acquisition and processing to the accuracy assessment of the point clouds obtained. This assessment will be carried out by using different statistical metrics such as the relative measurement error, the relative measurement accuracy as well as the cloud-to-cloud error by means of non-parametric variables such as the median and the NMAD.

The study case use for comparing both sensor is the convent of Nuestra Señora de Gracia in Avila, Spain, a religious complex from between the sixteenth to eighteenth century, with a variety of constructive solutions made in masonry and wood. The results are revealing that the wearable mobile system is appropriate for the digitalization strategy, providing the required level of quality with a reduced time with respect to the terrestrial laser scanner.

CODE 317**THE INTANGIBLE CULTURAL HERITAGE THROUGH DIGITAL INVENTORIES. CASE STUDY IN MÁLAGA, SPAIN**

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KEYWORDS: Intangible cultural heritage; Technological platforms; Local communities; Citizenship participatory processes.

ABSTRACT

This research explores how to make intangible cultural heritage (ICH) visible in technological platforms, with special emphasis on the agents involved and the participatory processes carried out in its cataloguing and protection. For this, a series of participatory actions have been carried out to identify the elements of intangible heritage value together with local communities in the city of Malaga, and they have been disseminated through a digital platform on heritage: malakanet (<http://malakanet.adabyron.uma.es/>). The different materials obtained in the participatory process - interviews, videos and photographs (many of them produced by the local community) make the ICH visible from the point of view of neighbours, entities and other local agents.

In addition, all the information obtained has been analysed and categorized, drawing up some worksheet on the intangible elements and singularities, which have been made together with local agents. The preparation of the catalogue is understood as an open process that can be updated over the time together with local communities. The results obtained from the participatory process -both catalogue sheets and additional materials prepared by the local community itself - have been incorporated into the digital platform for their dissemination. It is expected that these materials will have an archival value and can be a useful tool for researchers and practitioners on ICH in the future.

CODE 187**ACCESSIBILITY AND CULTURAL HERITAGE: THE CASE STUDY OF THE
BRAZILIAN FEDERAL SUPREME COURT PALACE USING THE MATRIX OF
AUTHENTICITY AND ACCESSIBILITY****Máximo, Marco Aurélio da Silva^{1*}; Ferreira, Oscar Luís²**

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e-mail: oscar@unb.br, web: <http://www.unb.com.br>**KEYWORDS:** Cultural Heritage Adaptation; Authenticity; Accessibility; Brazilian Federal Supreme Court Palace; Matrix A&A.**ABSTRACT**

Cultural heritage conservation, including adaptation for accessibility, requires capability to face challenges and implementation of actions to avoid authenticity lost, for example. Access to cultural heritage is a duty and a right of all, and cultural heritage sites should be as accessible as possible but preserving its values. Considering that accessibility legal requirements and heritage buildings and sites particularities sometimes may be in conflict, the Matrix of Authenticity and Accessibility (Matrix A&A) has been an important method to investigate what is necessary to adapt and the risks to heritage. This method has been applied in many case studies in the last ten years in different types of heritage buildings and sites. To investigate how accessible and to identify restrictions and opportunities, this paper presents the application of the matrix to the Brazilian Federal Supreme Court Palace in Brasília, an important modern architectural building signed by Oscar Niemeyer and built between 1958 and 1960. Despite of some restrictions, main results show that there are many possibilities of adaptation to provide accessibility. The Matrix of Authenticity and Accessibility presents the necessary subsidies for guiding project design and intervention work, contributing for cultural heritage promotion and diffusion.

CODE 40**HBIM & GIS INTEGRATION FOR THE 3D VISUALISATION OF VIRTUAL LIBRARIES IN EXISTING BUILDINGS: A CASE STUDY**

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KEYWORDS: HBIM; GIS; Information management; Virtual 3D library.

ABSTRACT

It is a reality that in order to refurbish and manage an existing building, it is necessary to have access to all possible information that has been generated regarding to the building. This need, on most occasions, is hindered by the unavailability of pre-existing documentation and because of the different agents involved in the refurbishment process and subsequent use of the buildings do not provide the information generated.

BIM is a collaborative work methodology that assists to integrate all the information generated on a building, serving as a container or virtual 3D library where all the contributions are recorded and synchronised, thus making them accessible at any time and place, helping to prevent information from being lost and to avoid errors, and, consequently, to be more efficient in terms of time and cost. Furthermore, BIM or HBIM models -as they are known in the heritage field- can be integrated into other models on a larger territorial scale, i.e. GIS (Geographic Information Systems) models, thus allowing collaborative work and information storage to go beyond the building level, integrating other contents related to the surrounding built environment.

The aim of this contribution is to integrate the HBIM model, generated to constitute the 3D virtual library of the refurbishment process of a historic building, into an urban scale GIS model.

CODE 209**THE RESILIENT CONSTRUCTION SITE OF THE HISTORICAL CENTERS.
A CASE STUDY****Rotilio, Marianna^{1*}; Laurini, Eleonora¹; De Berardinis, Pierluigi¹**

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When a catastrophic event occurs, it is necessary to implement strategies aimed at achieving the goal of rebuilding entire communities and the sites in which they live. The study of the state of the art, especially in relation to the recent seismic events that hit Central Italy, highlighted how the scientific community is investing in the so-called “resilient” reconstruction, able to exploit technological innovations, and in the concept of “risk management”. This article intends to illustrate a research that aims to merge these two aspects, in relation to the management of the post-earthquake construction site of historic centers. The research was born from a study already carried out by the authors which led to the definition of the so-called “construction site plan”, further analyzed here in terms of resilient response to further risks. The construction site plan was created as a superordinate planning tool that allows the reconstruction process to be managed through common rules. A programmatic tool that, on the one hand, allows the rational management of works, on the other, implements safety, as it is able to predict and therefore mitigate risk conditions. This construction site plan was implemented through the use of BIM and GIS software, and the methodology developed was validated in a case study in Abruzzo, Italy.

CODE 210**GUNPOWDER HOUSE - VALPARAÍSO AN URBAN ARCHAEOLOGICAL SITE AND ITS HERITAGE RECOVERY****Kaplan, Paulina**

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KEYWORDS: Archaeological heritage; Heritage recovery; Archaeological restoration.

ABSTRACT

At the beginning of the 19th century, the gunpowder house was being built in Valparaíso, “El Polvorin” that had to stock about 800 quintals of gunpowder, which allowed it to supply the entire defensive system of Valparaíso coast. In October 2, the year of 1807, the construction of the gunpowder House is approved. Since it is very important to create an enclosure that had the capacity to store war supplies and supply the defensive system. At the same time, it was essential to solve the deposit of the gunpowder in transit, which until that moment was kept in the warehouses of the Port. This location had to be changed and located away from the urban radius, and in a hidden place so as not to be seen by the enemies. In this way, the Jail hills was the appropriate place for the installation of a gunpowder house

The gunpowder house located on the grounds of the former Valparaíso jail is a testimonial construction of a system of buildings destined for this type of function in America. In turn, it is part of the old fortification system that Valparaíso had several centuries ago. Faced with the declaration of Valparaíso as a World Heritage Site, the recovery of these buildings contributes to enriching the history of the Port since they are the legacy of a period within the Hispanic history of Valparaíso. The gunpowder house had serious structural damage to its vault, assents that endangered its stability. Currently it was reinforced with metal elements to support the structure of the barrel vault. Added to this is a series of interventions that have been carried out over time, which have deteriorated not only its structure but also its architectural formality, distancing the work from its original appearance. Today the gunpowder house is a testimony of an urban archaeological site, in an active urban environment inserted in the current Cultural Center where Valparaíso prison was located, which functioned until the end of the 20th century.

CODE 215**REVIEW OF THE MANAGEMENT OBJECTIVES OF THE WORLD HERITAGE
DECLARATION OF ÚBEDA AND BAEZA****Hervás-Molina, María¹; Loren-Méndez, Mar²**

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KEYWORDS: Úbeda and Baeza; UNESCO World Heritage site; Cultural tourism; Management plan, Citizen participation.

ABSTRACT

The architectural and urban design of the 16th century were essential to introduce the ideas of the Renaissance in Spain, later exerting an important influence in Latin America and being an outstanding example of civic architecture and Renaissance urban planning. These values made possible the international recognition that crystallized in the declaration of World Heritage by UNESCO of the cities of Úbeda and Baeza in 2003.

The declaration provides a management model that aims to consolidate a brand of heritage quality, with a focus on protection, dissemination and recovery common for the two cities. Heritage management is based on economic reactivation and social commitment to the 'reevaluation of the historical city' with three objectives: 1. economic and business promotion that prioritizes the sustainability of tourism and productive activities; 2. the rehabilitation and improvement of residential heritage; and 3. the promotion of the character of these cities within the framework of cultural tourism.

Almost twenty years after this declaration, we carried out a critical review of the management plan and its objectives, in dialogue with the present regulatory documents and operational guides, that nowadays guide the actions and interventions in the cities at regional, national and international level. We assess the actions carried out during these two decades in terms of architectural, urban and landscape rehabilitation. Since it is a declaration that includes two cities, we analyze whether these actions are taking into account this dual uniqueness, and therefore if they have incorporated the territorial scope of protection that integrates it in an olive grove landscape. In addition, we study the strategies that are being carried out and that are complementary to this urban and architectural heritage of the sixteenth century, in order to make this destination a more competitive cultural tourism destination compared to other Spanish and even international enclaves.

The study offers a diagnosis of the shortcomings and successes in the tourist approach to heritage values within the management plans, as well as the coherence and relevance of complementary strategies, the dangers of simplification, trivialization and even lack of knowledge of the heritage in the tourist experience of these two Andalusian cities.

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