

ARCHITECTURE HERITAGE and DESIGN

Carmine Gambardella

XVI INTERNATIONAL FORUM

Le Vie dei  
Mercanti



**WORLD HERITAGE and KNOWLEDGE**

Representation | Restoration | Redesign | Resilience

**ARCHITECTURE HERITAGE and DESIGN | 2**  
Collana fondata e diretta da Carmine Gambardella

## **ARCHITECTURE HERITAGE and DESIGN | 2**

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**WORLD HERITAGE and KNOWLEDGE  
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Scholars has been invited to submit researches on theoretical and methodological aspects related to Smart Design, Planning and Technologies, and show real applications and experiences carried out on this themes. Based on blind peer review, abstracts has been accepted, conditionally accepted, or rejected. Authors of accepted and conditionally accepted papers has been invited to submit full papers. These has been again peer-reviewed and selected for the oral session and publication, or only for the publication in the conference proceedings.

**Conference report**

300 abstracts and 650 authors from 36 countries:

Albania, Australia, Benin, Belgium, Bosnia and Herzegovina, Brasil, Bulgaria, California, Chile, China, Cipro, Cuba, Egypt, France, Germany, Italy, Japan, Jordan, Kosovo, Malta, Massachusetts, Michigan, Montserrat, New Jersey, New York, New Zealand, Poland, Portugal, Russia, Slovakia, Spain, Switzerland, Texas, Tunisia, Turkey, United Kingdom.

160 papers published after double blind review by the International Scientific Committee

## Table of content

- P 12** Preface  
Carmine GAMBARDELLA
- 13 ID 004**  
Drawings and Paradoxes: The Image and the Three Fictional Dimensions of Architecture  
Pedro António JANEIRO
- 19 ID 006**  
Reconstruction, Addition, Grafting, Overlapping and Subtraction. Five Approaches to Intervention in Historic Contexts  
Antonello MONACO
- 23 ID 009**  
The knowledge as an instrument for recovery and valorize the rural architecture in Sicily  
Andrea D' Amore
- 34 ID 011**  
An evaluation on how to implement the Historic Urban Landscape (HUL) approach in a critical case study: the city of Valparaíso, Chile  
Andrea ORTEGA
- 43 ID 012**  
From recovery manuals to historic and construction BUILDING INFORMATION MODELLING (H-BIM). Strategies for historical sicilian centres  
Tiziana CAMPISI, Daniela SIDELI
- 53 ID 013**  
SWOT analysis for the redesign of historic university building stock  
Simone LUCENTI
- 62 ID 014**  
Metric survey and possible representations of Historic Architectural Heritage: the case of the Santa Giustina Abbey  
Alessandro PIOVANO, Fulvio RINAUDO, Roberta SPALLONE
- 71 ID 017**  
Research and design in the area of Early Christian basilicas in Cimitile  
Pasquale MIANO
- 81 ID 018**  
The landscape as a testimony, or a resource for the future?  
Nadia FABRIS
- 87 ID 019**  
The newly founded centers in the Agro Pontino: from the local to the global, from the past to the contemporary, to the future  
Alberto BUDONI, Maria MARTONE
- 97 ID 020**  
Conversions and Resilient Materials  
Emanuele Walter ANGELICO

## Table of content

- 104 ID 021**  
Analysis of Masonry Ancient Neapolitan Helical Staircases  
Francesco FABBROCINO
- 112 ID 022**  
Recomposition of architecture in the historical city. The San Bernardino area  
in Padua, Italy  
Enrico PIETROGRANDE, Alessandro DALLA CANEVA
- 122 ID 023**  
Facades of Krakow's townhouses from the turn of the 19th and 20th century  
– protection and restoration  
Beata MAKOWSKA
- 131 ID 024**  
Sustainable rehabilitation and reconversion of Palácio da Rosa (Lisbon) in  
a dance school  
Sara CARVALHO, António LEITE, Jorge RIBEIRO
- 141 ID 025**  
Change of urban landscape in correlation with archaeological heritage in  
contemporary Serbia and knowledge  
Natasa ZIVALJEVIC-LUXOR, Nadja KURTOVIC-FOLIC, Hartmut PASTER-  
NAK
- 153 ID 026**  
The recovery of illegal settlements: a case study  
Claudia de BIASE
- 162 ID 027**  
Piazza Medaglie d'Oro and the Vomero hill in the Società pel Risanamen-  
to's projects in Naples. 1885-1964  
Elena MANZO
- 172 ID 028**  
The cycle highway RS1 in Essen: a model of green-oriented mobility to  
promote urban history  
Ilaria PONTILLO
- 177 ID 031**  
A place for technology transfer and digital techniques applications for sur-  
vey and representation: the ancient fort of Nagaur in Rajasthan, India  
Minakshi JAIN, Pietro MASSAI, Luca ROSSATO
- 187 ID 032**  
The Chinese house inside the ex-foreign concession in Hankou: description  
of Lifen  
Francesco MAGLIOCCOLA
- 197 ID 033**  
Literature as a representation of changes in urban landscapes after 1945  
(on Polish, Czech and Slovak examples)  
Joanna CZAPLIŃSKA

## Table of content

- 203 ID 034**  
App and Go Edutainment for Micro\_Cities on the Sicilian Ionian Coast  
Marinella ARENA
- 212 ID 037**  
Traditional Knowledge of Disaster-Resilient Design in World Cultural Heritage, Japan - For Consisting Cultural Conservation and Disaster Mitigation -  
Takeyuki OKUBO
- 220 ID 039**  
Geo-climatic applicability of sunspaces in European climates including resilience to climate changes  
Giacomo CHIESA
- 229 ID 040**  
Design of indoor climate-control passive systems in buildings: experiences for a PhD course  
Giacomo CHIESA, Mario GROSSO, Mehrnoosh AHMADI, Matteo BO, Giovanni MURANO, Marianna NIGRA, Elisa PRIMO
- 239 ID 041**  
The Sanctuary of Castel Petroso: reflections on architectural representation  
Piero BARLOZZINI, Fabio LANFRANCHI
- 247 ID 042**  
Abandoned Railways and Cultural Heritage. Networks for spread regeneration  
Francesca CASTAGNETO, Stefania DE MEDICI
- 257 ID 044**  
Innovative instruments of territorial environmental management: the need for a regulatory approach  
Michele RUSSO
- 263 ID 045**  
The Redesign of Boundary between River and Ground. A Technological-Environmental Approach for the Resilience of River Corridors and Health of Inhabitants  
Michele DI SIVO, Filippo ANGELUCCI, Cristiana CELLUCCI, Daniela LA-DIANA
- 272 ID 046**  
To save from oblivion and destruction. A historical-juridical perspective on the cultural heritage's protection  
Maria NATALE
- 280 ID 047**  
Structural morphology of the oldest Church in Capocastello (AV)  
Ingrid TITOMANLIO

## Table of content

- 288 ID 048**  
Seismic safety evaluation and push over analysis of the oldest church in Capocastello (AV)  
Ingrid TITOMANLIO, Giuseppe FAELLA, Vito IANNACCONE
- 297 ID 049**  
Ancient roads of Southern Etruria: historical evolution and digital investigation  
Michele MAGAZZU'
- 304 ID 050**  
PCM in the energy redevelopment of social housing  
Frida BAZZOCCHI, Vincenzo DI NASO, Ilaria TORTORELLA
- 314 ID 051**  
The Visibility of the Monumental Heritage and the Network Society  
Matteo Giuseppe ROMANATO
- 323 ID 052**  
Ziride and Hammadite palatial architecture and its influence on Norman architecture in Sicily  
Lamia HADDA
- 333 ID 054**  
A spatial multi-criteria analysis model to identify intervention strategies for the recovery of abandoned olive groves. The case study of Lucca Hills  
Simona BONELLI, Massimo ROVAI, Maria ANDREOLI
- 343 ID 055**  
Landscape redevelopment as a tool for the enhancement of rural areas. A project proposal for the case study area of Padule di Bientina (Lucca – Italy)  
Silvia MICHELOTTI, Massimo ROVAI, Maria ANDREOLI
- 353 ID 056**  
The reconstruction of an Image. The experiences of Quaroni and Piacentini in Basilicata  
Antonio BIXIO, Giuseppe DAMONE, Enza TOLLA
- 361 ID 057**  
The aggregation of the building elements in horizontal structures  
Francesco Pio ARCELLA
- 368 ID 058**  
New trends in local government policies: between the need for reducing land consumption and participatory urban regeneration models  
Marco CALABRO'

## Table of content

- 376 ID 059**  
The main pillars reconstruction of the Basilica di Collemaggio  
Alberto FRANCHI, Pietro CRESPI, Marco ZUCCA, Nicola GIORDANO, Nicola LONGARINI
- 383 ID 060**  
The Promotion of the cultural heritage: brand new challenge, same old problems  
Antonio LIGUORI
- 389 ID 061**  
The earthen architecture culture and Campidanese house. Strategies for recovery and enhancement of the Quartu Sant'Elena's Old Town Centre  
Alessandra PUSCEDDU, Mario CERASOLI
- 399 ID 062**  
Sicilian rural borghi, urban and architectural entities between concreteness and immateriality  
Alberto GNAVI, Silvia Maria RIPA
- 409 ID 064**  
The built heritage copied and replicated. Reproduction processes of the urban heritage: transcription, restitution and displacement  
Giuliana QUATTRONE
- 417 ID 065**  
The built heritage copied and replicated. Reproduction processes of the urban heritage: transcription, restitution and displacement  
José Miguel SILVA
- 427 ID 068**  
The role of Italian cultural heritage in sustainable urban regeneration. New references from four case studies  
Francesca ACCICA, Irene POLI, Chiara RAVAGNAN, Francesca ROSSI
- 436 ID 069**  
Smart Heritage Strategy: a new intelligence for resilient historical centers  
Chiara AMATO, Giulia BEVILACQUA, Silvia URAS
- 446 ID 070**  
An inclusive approach to Digital Heritage for knowledge and conservation of European assets: the INCEPTION project  
Federica MAIETTI, Federico FERRARI, Marco MEDICI
- 456 ID 071**  
"The commercial relations between Great Britain and the Kingdom of the Two Sicilies in the XIX Century"  
Vincenzo PINTAUDI

## Table of content

- 467 ID 072**  
“The Value of Social Media for Reconstructing Lost Heritage in the British Overseas Territory of Montserrat, Site of an Ongoing Volcanic Crisis.”  
Gracelyn CASSELL
- 477 ID 073**  
Architecturale experiences in the churches of the foundation centers of the “Opera Nazionale per i Combattenti”  
Riccardo SERRAGLIO
- 487 ID 074**  
Functional behaviours in the requalification of public residential buildings  
Carla CHIARANTONI
- 495 ID 076**  
Observing urban landscapes. View-points for the representation of contemporary city  
Antonella SALUCCI, Niccolò SARDO, Marta MAGAGNINI
- 505 ID 077**  
The Design to valorise local tradition in exhibitions for future generation  
Laura GIRALDI, Isabella PATTI
- 512 ID 080**  
Made in stone  
Agnieszka KOSIK WOLNY
- 521 ID 083**  
Integrating governance of the National Reserve of Coyhaique, Chile, into regional sustainable development  
Theresa TRIBALDOS, Stephan RIST
- 529 ID 084**  
Increasing resilience of Cultural Heritage Assets: the “BIMtoBAcademy” project  
Marcello BALZANI, Fabiana RACO, Theo ZAFFAGNINI
- 535 ID 085**  
Enjoyment of the Cuban Contemporary Architectural Heritage: an innovative cultural visitor route to connect the UNESCO site of Old Havana to the National Schools of Art  
Cristina COSCIA, Rocco CURTO, Valeria GADALETA, Jorge PEÑA DÍAZ, Diana ROLANDO
- 545 ID 086**  
Applying Resilience Thinking for the Cultural Landscape of the inner areas: new tools of knowledge and adaptive management  
Maria Rita PINTO, Katia FABBRICATTI, Lucie BOISSENIN



## Table of content

- 555 ID 087**  
The complex dialogue between contemporary language and preservation of the ruins in the restoration of Paul II's fortress at Cascia  
Stefano D'AVINO
- 563 ID 088**  
Landscape analysis of railway structures in heritage assessment: Bridges on the Victoria-Temuco railway line  
Ignacio BISBAL GRANDAL, Françoise Anais LOUBIÈS, Nicolás Andrés MORAGA HERRERA
- 573 ID 090**  
Architectural Representation: a Tool for Urban Regeneration The Colour Plan of Egadi Islands  
Angela Alessandra BADAMI
- 583 ID 091**  
From the traditional to the virtual museum: a strategic cultural, social, environmental and economic resource for Europe  
Cristiana CARLETTI
- 594 ID 092**  
Wedge-shaped bricks spires and domes. Construction and decorative aspects  
Francesco DI PAOLA, Giovanni FATTA, Calogero VINCI
- 606 ID 093**  
Pottery from the south-west area of the Castle of the Monte in Montella: the decorative repertoire  
Iolanda DONNARUMMA, Gaetana LIUZZI
- 617 ID 097**  
Principles of cultural landscape Restoration  
Sara POURYOUSEFZADEH
- 626 ID 098**  
The representation of complex systems. New communication strategies  
Maria Elisabetta RUGGIERO
- 633 ID 100**  
How the historical heritage affects the urban flow of people? The case study of Lecco  
Mattia ALBERGANTI, Chiara BONAITI
- 642 ID 101**  
The tomb of Henenu, Luxor, Egypt: underground surveying  
Ernesto ECHEVERRÍA, Flavio CELIS, Antonio MORALES, Fernando da CASA

## Table of content

- 651 ID 102**  
The preservation of the architectural heritage of the twentieth century: the laminar structures of reinforced concrete  
Monica MARTINEZ, Ernesto ECHEVERRIA, Gonzalo GARCIA-ROSALLES, Kevin MORENO
- 659 ID 104**  
Decline and Resilience of a Mediterranean City: the Case of Syracuse during Thirteenth Centuries  
Elina GUGLIUZZO
- 665 ID 105**  
The Sanctuary of Santa Maria delle Grazie at Fornò: studies for the restoration and seismic strengthening  
Alberto CUSTODI, Nicola SANTOPUOLI
- 675 ID 106**  
Urban design and sprawled archaeology. From the “ancient vs new” dichotomy to pre-existence as design material  
Raffaele SPERA
- 684 ID 107**  
Material and immaterial heritage as a strategic resource facing structural shifts: the case of the Fès-Meknès region (Morocco)  
Letizia DI PASQUALE, Maria Rita GISOTTI
- 694 ID 109**  
Derna: a gateway of Libya. The ethical value of identity and the vision for the birth of a new urbanity  
Calogero MONTALBANO
- 704 ID 110**  
“...But what use is this art history?”  
Anna MANDIA
- 709 ID 111**  
The representation for the use of hidden heritage: the case of Genoese artificial caves  
Massimo MALAGUGINI
- 719 ID 112**  
The color of the city. Restoration and conservation of the painted facades of Palazzo Boschetti-Dalanzo then Avagnina in Carrù  
Maria Paola MARABOTTO
- 728 ID 113**  
A Resilient Environmental and Social Design Strategy  
Francesca MUZZILLO, Fosca TORTORELLI

## Table of content

- 732 ID 115**  
Natural disaster and environmental risks. Facts, needs and challenges in Italy  
Benedetto DE VIVO
- 738 ID 116**  
Ductility-based incremental analysis of masonry structures strengthened with composites  
Giancarlo RAMAGLIA, Francesco FABBROCINO, Gian Piero LIGNOLA, Andrea PROTA, Gaetano MANFREDI
- 747 ID 117**  
The technology of reinforced concrete elements.Determination of project parameter: concrete cover  
Roberto CASTELLUCCIO, Maria INFANTE, Veronica VITIELLO
- 757 ID 118**  
The “Cartilla de mantenimiento” as a tool for the protection and maintenance of the earthen architectural heritage in Tunja, Colombia  
Elena ZANET, Francesca DE FILIPPI
- 767 ID 119**  
The Deception of Colour: Digital Reconstruction of finctae et pictae Architectures  
Gabriella LIVA
- 776 ID 120**  
The role of overstrength in damage propagation and monitoring of architectural heritage  
Bernardino CHIAIA, Antonio VENTURA
- 783 ID 121**  
ICTs to train on World Heritage and Tourism: the case of “Tourism Management at UNESCO World Heritage Sites” MOOC  
Ilaria ROSANI, Silvia DE ASCANIIS, Maria GRAVARI-BARBAS, Lorenzo CANTONI
- 792 ID 122**  
Local identities & excellences. An industrial network to re-produce uniqueness through waste reutilization  
Elisabetta BENELLI, Laura GIRALDI, Francesca FILIPPI, Jurji FILIERI
- 799 ID 123**  
Sinkhole hazard in the metropolitan area of Naples,Italy  
Anna SCOTTO DI SANTOLO, Melania DE FALCO, Giovanni FORTE, Antonio SANTO
- 807 ID 124**  
A requalification project hypothesis for the Bagnoli/Agnano (Naples, ITALY) ex NATO Headquarter Area  
Mariateresa RUGGIERO

## Table of content

- 816 ID 125**  
Strategy to re-active an urban landscape  
Valeria SCAVONE
- 823 ID 128**  
Two outstanding examples of vernacular architecture in Talas town, Anatolia  
Duygu TURGUT
- 831 ID 129**  
Paul Bellot architecture: between resilience and redesign of “sacrum”  
Maria Carolina CAMPONE
- 841 ID 133**  
Greek Orthodox merchants in Western Mediterranean sea: commercial and canonical matters  
Antonio MATASSO
- 845 ID 134**  
Protection and Integration of linear watercourse cultural landscape in urban development ----- A case study of Orléans and Yangzhou  
Liang PENG
- 857 ID 136**  
Russian approaches to estimation and experience of monitoring of radon radiation  
Andrey V. VASILYEV
- 862 ID 137**  
Approaches and results of estimation of noise impact to the health of population  
Andrey V. VASILYEV
- 870 ID 138**  
Automobile transport noise modeling and estimation in town conditions  
Andrey V. VASILYEV
- 875 ID 139**  
Majolica and Architecture. Treatment of the lacune. The case of the bell tower of San Paolo Bel Sito  
Saverio CARILLO
- 885 ID 140**  
The historical context and the urban regeneration  
Federica CAPRIOLO

## Table of content

- 894 ID 141**  
Typological classification of vaulted structures in masonry churches  
Daniela CACACE, Gianfranco DE MATTEIS
- 904 ID 142**  
Innovative systems for the redevelopment of historical buildings: BIM application  
Simona COLAJANNI, Giusy Emanuela LO CACCIATO, Achille Roberto PORCASI
- 914 ID 143**  
Evaluation of the indoor comfort of the Arabic-Norman architecture for its valorization  
Simona COLAJANNI
- 922 ID 144**  
Structural behaviour of masonry vaults according to architectural types  
Gianfranco DE MATTEIS, Daniela CACACE
- 932 ID 145**  
Design with Nature: The connection between Critical Regionalism and Biomimicry in a Moroccan village  
Pedro MARTINS-MOURÃO, Pedro JANUÁRIO
- 942 ID 146**  
Preservation of historic buildings: two examples in Sant'Agata de' Goti, Italy  
Annachiara PIRO, Annalaura VUOTO, Filomena de SILVA, Pierpaolo D'AGOSTINO, Fulvio PARISI, Francesco SILVESTRI, Anna SCOTTO di SANTOLO
- 952 ID 147**  
Sports Architecture: the soccer stadiums of the twentieth century in Brazil and Portugal  
Beatriz ATTA, Pedro JANUÁRIO, Jorge BOUERI, João SOUSA MORAIS
- 960 ID 148**  
Data taking and quality control for complex surveys: Case study Sagrada Família  
Juan CORSO, Jordi CASALS, Adria MARCO, Daniel LÓPEZ, Pilar GARCIA ALMIRALL
- 971 ID 151**  
Territory visions: dimensions of observing, measuring and returning  
Laura FARRONI, Marco CANCIANI, Matteo Flavio MANCINI, Silvia RINALDUZZI
- 981 ID 153**  
Reuse or Recycle?  
Ludovico ROMAGNI

## Table of content

- 989 ID 159**  
Survey between protection and orientation of transformations. The case study of Florida  
Rita VALENTI, Claudia FARACI, Sebastiano GIULIANO, Emanuela PATERNO, Flavio SPADARO
- 998 ID 160**  
Public Buildings accessibility in Fortaleza's Historical Center  
Camila BANDEIRA PINHEIRO LANDIM, Pedro Miguel GOMES JANUÁRIO, Márcia Maria VIEIRA HAZIN, Geórgia MORAIS JEREISSATI
- 1009 ID 161**  
The museum building and its role in conservation of artifacts in Albania  
Etleva BUSHATI, Florian NEPRAVISHATA
- 1019 ID 162**  
The use of new technologies in the commemoration projects of the centenary of the apparitions of Fatima  
Geórgia MORAIS JEREISSATI, Pedro Miguel GOMES JANUÁRIO, Márcia Maria VIEIRA HAZIN, Camila BANDEIRA PINHEIRO LANDIM
- 1029 ID 163**  
The implementation of the Smart City paradigm in complex and user-centric domains  
Mariacarla PANARIELLO
- 1037 ID 164**  
Traditional games and culture  
Antinea AMBRETTI
- 1041 ID 165**  
The "Right" to the quality of the "Preservation" for Italian architecture of the Second half of the 20th century  
Carla BARTOLOZZI, Gentucca CANELLA
- 1051 ID 167**  
Design 4.0. Practices and processes of diffuse and circular design for the enhancement and development of local cultural heritage  
Jurji FILIERI, Elisabetta BENELLI, Laura GIRALDI
- 1060 ID 171**  
Historic urban centers. Construction characters and seismic vulnerability  
Tiziana CAMPISI
- 1070 ID 172**  
Internet of things and artificial intelligence technologies preserve cultural heritage  
Marin MARINOV, Maria KOKORSKA

## Table of content

- 1078 ID 175**  
Italian grain silos from the 1930s: inventory, knowledge, conservation and reuse  
Stefania LANDI
- 1088 ID 178**  
Destructive tests for mechanical characterization of in situ structural timber  
Francesco GUARINO, Alberto MANDARA, Gianfranco DE MATTEIS
- 1098 ID 179**  
Correlation between NDT results and mechanical strength of structural timber  
Gianfranco DE MATTEIS, Francesco GUARINO, Alberto MANDARA
- 1108 ID 180**  
From information to knowledge Building new learning strategies in heritage field through graphics and new technologies  
Marina PUYUELO, Pedro FUENTES, Mónica VAL
- 1118 ID 183**  
Three Schools: Torino, Avellino, Palermo  
Efisio PITZALIS
- 1128 ID 184**  
Mediterranean Bio-Cultural Landscape: network of expertise  
Marina FUMO, Gigliola AUSIELLO, Monica CANNAVIELLO, Antonella VIO-LANO
- 1138 ID 185**  
Virtual community content sharing to support decision making process in protection, conservation and promotion of cultural heritage and landscape  
Antonio TUFANO, Roberto VALENTE, Modestino MATARAZZO, Enza GRAZIANO
- 1148 ID 186**  
Design 4.0. Practices and processes of diffuse and circular design for the enhancement and development of local cultural heritage  
Caterina GATTUSO
- 1155 ID 187**  
Hidden river: recovering the memory of a city  
Maria Grazia CIANCI, Francesca Paola MONDELLI
- 1165 ID 188**  
The role of evaluation in B.I.M. models: from the representation to the simulation of the design  
Giovanna ACAMPA, Fabiana FORTE

## Table of content

- 1172 ID 189**  
Adaptive and dynamic facade: a new challenge for the built environment  
Sergio SIBILIO, Roberta IAVARONE, Simona MASTANTUONO, Maria MANTOVA, Luigi D'AUSILIO
- 1183 ID 190**  
Preliminary energy analysis of the school building stock in the Province of Caserta  
Sergio SIBILIO, Nicolò FALCIONE, Anna IMPROTA, Antonio ROSATO
- 1191 ID 193**  
Post-seismic rebuilding in Irpinia and resilience  
Maria Antonietta FALCI
- 1201 ID 194**  
A simplified analysis for seismic risk assessment of reinforced concrete school buildings  
Gianfranco DE MATTEIS, Pasquale BENCIVENGA, Francesco GUARINO, Carmela NOLA
- 1210 ID 196**  
The Mudéjar Style: An interpretation key of the Ibero-American Baroque architecture  
María Fernanda GARCÍA MARINO
- 1220 ID 197**  
The rediscovery and enhancement of the historical "Wool Road" through its recognition and reuse project  
Paola CONDOLEO, Andrea ROLANDO, Daniela ORENI, Alessandro SCANDIFFIO
- 1230 ID 198**  
Sewell mining settlement: Construction of a unique landscape as an adaptive process to a complex and hostile territory  
María Dolores MUÑOZ, Ignacio BISBAL
- 1240 ID 200**  
REDESIGN + RESILIENCE= Stories of Alternation  
Maria Dolores MORELLI
- 1247 ID 201**  
A resilient pedagogy. The LANDesign® Project for "school-work alternation"  
Enrica PAGANO
- 1256 ID 202**  
Know to preserve: Archaeological remains of the triconch architectures in Turkey  
Danila JACAZZI, Raffaella FIORILLO



## Table of content

- 1264 ID 203**  
Green infrastructures and Eco-Planning: the Aversa conurbation  
Salvatore LOSCO
- 1274 ID 204**  
A New Role of Museums in Industrial Type Cities and Renovation Programs for the “Center-Periphery” Opposition: the Case of the Museum Quarter Togliatti Concept  
Elena SHLIENKOVA, Elena SPERK
- 1285 ID 205**  
Documenting the Architectural Heritage. From the survey to the three-dimensional modelling  
Pamela MAIEZZA
- 1293 ID 206**  
The connection between the Architectural Roman heritage and the Theory of Nodes as a management tool  
Isabel TORT AUSINA
- 1302 ID 207**  
Productive green in the city: opportunities for eco-oriented transformations  
Raffaella DE MARTINO, Barbara DI VICO, Rossella FRANCHINO, Caterina FRETTOLOSO
- 1313 ID 208**  
Aldo Rossi: Berlin, 1960-1997  
Maria Luigia DI BENNARDO
- 1322 ID 211**  
The Real Estate Fund for the redevelopment of Public Administration Properties  
Francesco VERDE
- 1331 ID 212**  
Complex Representation of Knowledge  
Gilda EMANUELE
- 1335 ID 226**  
Designing the resilience. A masterplan for the Opportunity Areas of Bromley  
Giovanni BELLO
- 1341 ID 230**  
The evolution of information disclosure through the Open Institutes  
Luciana ABATE

## Table of content

- 1351 ID 231**  
Knowledge and representation between ethics and aesthetics  
Rosaria PARENTE
- 1361 ID 232**  
The Future of Representation: parametric modeling in the HBim environment  
Giuliana CHIERCHIELLO
- 1371 ID 270**  
Representing World Heritage properties, cultural landscapes and contemporary architectures: Amsterdam and Rotterdam  
Alessandro CIAMBRONE
- 1382 ID 271**  
Itineraries of urban identity  
Isabella PATTI



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## A place for technology transfer, digital survey and representation techniques: the ancient fort of Nagaur in Rajasthan, India

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### Abstract

The existing layout of Ahhichatragarh fort was created in the 12th century in the ancient city of Nagaur, one of the first Muslim strongholds in Rajasthan, Northern India.

The fort has been heavily altered over the centuries. The 25-year project for its rehabilitation (and still in progress), has involved the training of many artisans adhering to principles of minimum intervention. At the same time, several capacity building programmes were implemented in order to increase also the skills of professionals and experts of the conservation field.

In this framework, in a research path carried out over 5 years, the main focus of the activities has been the evaluation of technologies to be applied to Indian Cultural Heritage.

The pilot projects and investigations carried out by international teams aimed at identifying functional methods for the analysis, representation and diagnosis of the architectural heritage of the complex.

The fort requires continuous monitoring and planning of interventions aimed at the preservation of its historical value. This might be more efficiently accomplished exploiting the advantages offered by new technologies, such as non-invasive analysis and digital techniques for heritage enhancement, tools that are not yet functionally integrated in the conservation processes in India.

As required by local partners, the project was based on a wide range of records and it has been able to produce different research outputs.

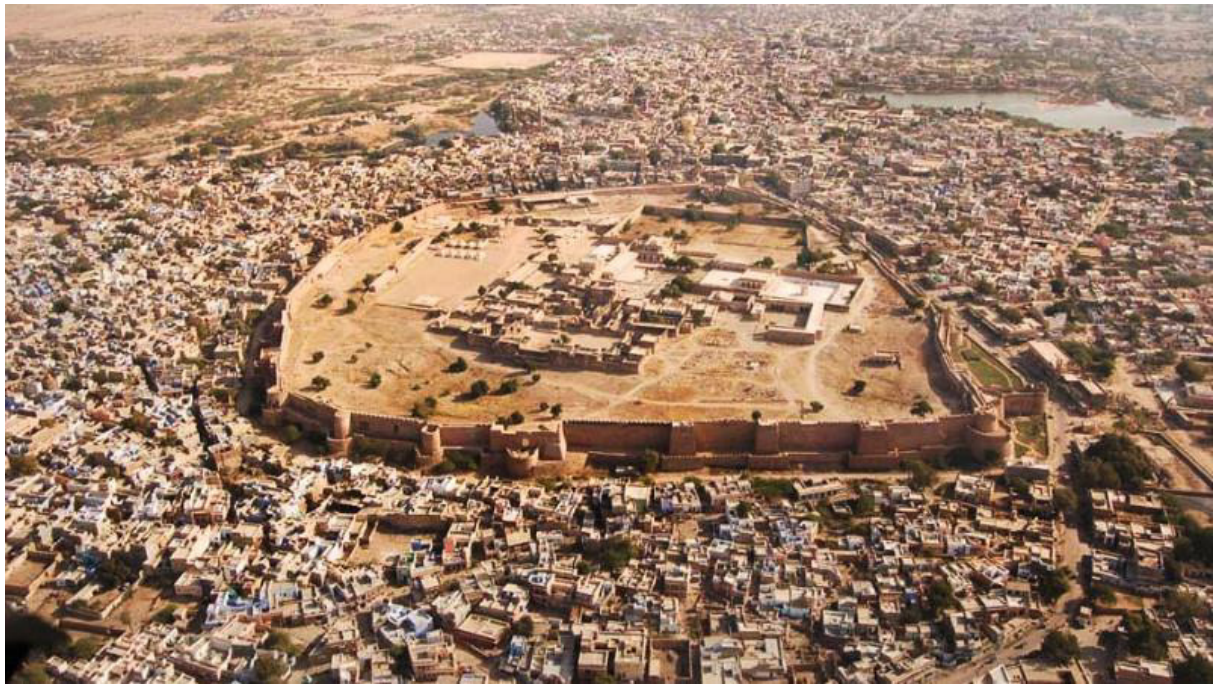
**Keywords:** Technology, Survey, Representation, Digital Techniques, Conservation

### 1. Introduction

The Ahhichatragarh is the fort of Nagaur, a city in Northwest India, (two hour drive from the famous "Blue" city of Jodhpur) in the state of Rajasthan, administrative headquarters of Nagaur District.

The fortification complex was located on a caravan route and encompasses over 145.686 Sq. Meters land with a 1.539 meter long, 12m to 18m high fort wall, circumventing 5 palaces, 48 ancillary buildings, 5 temples and 2 mosques. The fort itself probably dates back to its earliest form to the 4th century, when a mud outpost was built at the crossroads of developing trade routes. The mud fort was then replaced by a stone structure in 1119-21 and later expanded by successive rulers until the mid-18th century, while the numerous structures and their painted decoration date principally to the reign of Bakhat Singh (1724-51) (TILLOTSON, 1987). The fort is one of the finest examples of Rajput-Mughal architecture – but over the years, this large fortified complex of palaces, elaborate gardens, temples and a mosque had fallen into ruin. Unfortunately after 1947, year of the independence of India, the fort was used as the office of the district administrator. The gardens were allowed to die, painted walls were whitewashed, and decayed stonework was left unrepaired, allowing parts to collapse. (JAIN et al., 2009).

A series of Getty Foundation grants (The Getty Foundation has been a major funder of conservation at Nagaur since 1993) has enabled the Mehrangarh Museum Trust of Jodhpur to undertake a multi-year conservation of the fort, using a blend of both traditional building methods developed by local craftsman and more modern scientific techniques in cooperation with international partners.



**Fig. 1:** The Ahhichatragarh fort, heart of the Nagaur city, in Rajasthan state, India

### **1.2. A precinct within Ahhichatragarh walls: the Ranvas**

Ranvas precinct is located at the Western end of the Fort, with its guarded separate entry. This is the first safety device; many such devices had been subtly built in for royal ladies. Through a small narrow gate on the North side, an auspicious direction for entrance, one enters in open palanquin court. The small size of the gate is suggestive of a small mode of transport, the hand carried palanquins. There would be several screening layers for entry and exit of royal ladies. Only known people were allowed to enter into the Ranvas area. The plinths in the court are for boarding and alighting the palanquins, from here onward it is a pedestrian path. The temple of Goddess is located where the first 200 meters passage is wide. Several small spaces were found: their historic functions are unknown. A turn to the right, opens into a narrow pathway, which leads to entrances to three Havelis. The end of the path is a real surprise, a large open space with a semi open pavilion, known as Ranvas Baradari. On the East there is the Bhakt Sigh Palace, the main complex, with a direct internal entry presumably used by the king or queens, when they would go to participate in official meetings. On the opposite side there is a swimming pool built where historically were located bath area or toilets with their drain lines.

Each of this two story havelis have its own hierarchical open, semi-open and enclosed spaces. The ground floor façade walls are solid, except for the main door: that was found hidden behind low walls in 1993. One room and some terraces are on the first floor, with articulated carved stone and alcoves for lamps, thus making the visual composition as low height, rustic, receding, and meandering look. The small windows of the outer wall show a view of huge Fort wall, constantly reminding the historical presence.

Although connected by a common walls, each of the havelis is self-sufficient and independent. A semi-open pillared veranda is provided for the daytime activities. A single bay of private spaces runs along both the sides of this veranda on the ground floor: either on East or North side of the private space there is the open service area that separates the two houses. In the past, toilets must have been located there, since a drain and a gap for removing night soil were found. The first floor room and terrace are private and safer. Articulated with jharokhas overlooking the court. Size variation in plan has occurred because of addition or subtraction of several bays. The construction method is of a composite nature using columns and walls where semi-open spaces are required, and with infill walls, where enclosed rooms are required. Construction is in stone masonry with lime mortar. Square Stone columns sit on base with capitals are non-decorative. Stone beams are supported with arcaded brackets, and joined with iron clamps (JAIN et al., 2009).

### **1.3. Conservation work at Ranvas precinct**

While adhering to the original function, the Ranvas precinct offered the rich opportunity of reuse because of its unique position, isolation, as well as proximity to main palaces. It was seen as the possible revenue generator for the maintenance of main palaces.



**Fig. 2:** The Ranvas precinct at Nagaur fort

Conservation and development works were taken up simultaneously to minimize duplication of efforts. Accommodation for fifty-two people in thirteen double and twenty-six single rooms have been provided. Common facilities like, lounge (Ranvas Baradari), dining, kitchen, offices, staff quarters, etc. are placed inside existing structures. New spaces such as swimming pool, some staff quarters, electric generator, water cleaning plant, drainage and solar plant have been added. One part has been renewed and re-used as a Museum for a deeper explanation of the whole restoration of the fort.

Conservation works have used wood and stone, old for walls and new for decorative works. Lime and sand with addition of concoction made with gud (raw sugar), gugal (binding agent) and fanugreek (methi) formed the mortars. Sculptures recovered from Fortwall are placed in many places. However, these were done with minimal disturbance to the historic character.

For shared and new common spaces, a historic architectural language was used. The conservation policy included inserting new infrastructure.

The historic pattern of access was maintained, recreating the notions of sequencing, the gradual opening up of vistas and heightened emphasis on security.

Work of cleaning, lime soaking, and removal of accretions, structural replacement of stone beams and brackets was taken up first. Rusted iron clamps were replaced with stainless steel clamps. All stairs were repaired for equal sized risers, and steel railings are provided. Historical elements, found on the site such as earthen pots, jalis, alcove features, zharookhas, railings and decorated entrances have been repaired and restored.

To enhance the historic ambience, shamianas were introduced. Shamianas are the historic temporary devices for shading in the arid areas. The large pieces of Colorful Rajasthani textiles are hanged over the open areas of Baradari, terraces, haveli courtyards and in entrance.

Sensitive signage, furnishings, finishes, and knick knacks have enhanced the historic euphoria. supported by research and experience. This has since been accomplished with sensitive design considerations, responsive both to the historic values and contemporary needs.

The conservation plan has attempted to revive the Ranvas precinct as a public tourist place. This architectural monument is put under controlled use, to stop its decay.

To establish its historic distinction both innovative and traditional methods were used in conjunction (JAIN et al., 2009).



**Fig. 3:** An enclosure after conservation works

Even though Mughal authority diminished considerably in the eighteenth and early nineteenth centuries the place is nowadays of outstanding value since the imperial Mughal architectural style and taste served as a model for that in developing splinter states (ASHER, 1992).

## **2. The Technology transfer project**

The approach aiming at the integration of traditional management tools and digital tools for enhancement take into deep consideration also the intangible aspects of this heritage: local traditions, cultural behaviours, and design processes very often related to local culture and needs (especially in India). As stated by Yehuda Kalay, Thomas Kvan, Janice Affleck in *New Heritage: New Media and Cultural Heritage* "The complement of traditional methods to cultural heritage management has been augmented with the introduction of digital or new media. [...] Digital media can be utilized for much more than re-creation or re-presentation of physical entities. It has the capacity to become a tool to capture both the tangible and intangible essence of cultural heritage and the society that created or used the sites" (KELAY et al., 2008).

As identified by J.T. Dallen and N. Gyan (DALLEN and GYAN, 2009) one of the most frequent threat to cultural heritage sites (in Global South Countries) is the lack of management. In this framework participatory processes and audits with involvement of students and researchers can improve the knowledge of problems related lack of planning and maintenance. "Recently, digitization has attracted increasing interest not only in museology and computer science, but also in economics and managerial literature. Scholars have tried to analyse how technological innovation is reshaping the role and mission of museums as producers and distributors of cultural content and investigate the new business model that emerges" (L. LAZZERETTI, A. SARTORI, 2016).

In order to develop conservation practices for ancient buildings, activities such as conferences and colloquia have been held during time of this research. The training of local staff and related officials in maintenance procedures has been a key point for the activation of both sensibility and awareness toward preservation.

In some cases a combination of classroom exercises and on-site demonstrations helped to familiarize staff with the conservation of modern heritage. In India for instance, audience of these workshops has been expanded to include students, professionals, teachers, private companies involved in conservation field. Furthermore Digital and social gaps must be bridged in order to provide access and added value to citizens. ICT tools provide an incredible opportunity to encourage growth and prosperity. Digital content and services empowered by broadband communications, both wired and wireless, could have a significant impact on society. One of the first steps in this direction is to promote human networking and the exchange of experiences and skills amongst different groups and communities" (RONCHI, 2008, p. 14).

These events could be aimed at professionals with the purpose of transferring both practical competences and contextual analysis. Consultants and researchers involved in conservation field have been invited to present their analytical methodology, results and conclusions and to frame their research so that professionals can place their work within a broader field of study.

As part of this process of public awareness further promotion and dissemination may also be achieved by publishing articles in specialized journals and presenting papers at academic conferences.

In this framework Indian teachers play a vital part. To make university teachers well versed with historic buildings there should be more lectures on this topic as well as other activities provided for better understanding cultural heritage (SRIVASTAVA, 2015). A future step in this field will be the involvement of local municipalities such as Jodhpur city toward the organization of programmes planned on short term and long term basis for professionals at every stage or level of education.

Through this study, by several pilot projects that have been carried out since 2013, it was possible to create awareness about the fundamental conservation principles underlying maintenance by the use of technologies of historic heritage in India providing an opportunity to formulate methodologies that were part of the process of learning by doing on site.

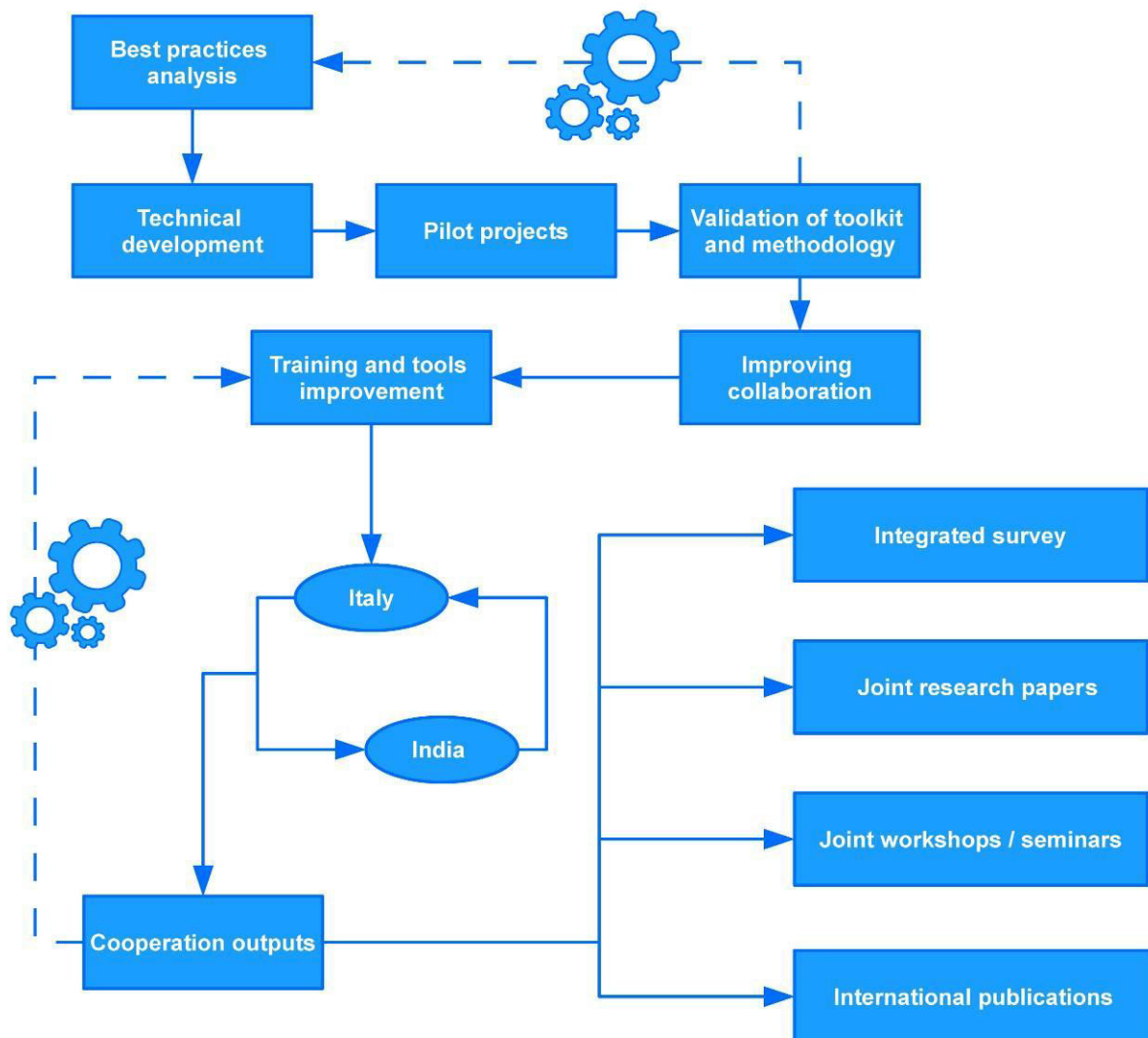


Fig. 4: The project methodology and related outputs

### 3. The pilot projects

As stressed by Karni Singh, in Nagaur Fort, conservation management and practice on historic sites are strictly connected (SINGH JASOL et al., 2008): it is possible to plan a future for this heritage sites only by means of a strong work cooperation between architects and planners, in order to define the best management framework for the future.

This is why the Mehrangarh Museum Trust (KHAWAS AND KULSHRESHTHA, 2017) was established in 1972 by Maharaja Gaj Singh II, managing trustee and owner of the Mehrangarh (Jodhpur) and

Ahhichatragarh (Nagaur) Forts. Since its creation the trust tried to define the best way to conserve and reuse heritage sites. Approaching the renovation of Nagaur Fort the idea of restoration was already well established and clear: the Fort should be a place for capacity building actions in the heritage conservation field. Soon after the first international grant for restoration, series of workshops were carried out to make on one side the inhabitants and on the other side craftsman aware of what was happening inside the fort and make them understand the context of conservation.

From the good feedbacks received both from residents, researchers and students, Mehrangarh Museum Trust along with conservators decided to continue the dissemination of these workshops focused on Cultural Heritage preservation instead of the mere use of it a touristic place having in mind the words of one of the conservation architects who has been working on the fort, Prof. K. Jain "We are still grappling with this misplaced notion of beautification of a heritage site in order to satisfy expectations of visitors who come to the site." (JAIN, 2017).

Nowadays the experience of workshop continues with students that comes all around the country and sometimes from abroad and sponsors have increased in number. Directed by the architects and the engineers of the Trust since 2013 the workshops involved many expert from numerous countries and with dissimilar views.

### 3.1. 3D laser scanner and diagnostic survey

One of the first initiatives carried out within this research framework by the DIAPReM research centre (University of Ferrara Department of Architecture) tried to foster international cooperation and technology transfer. The survey campaign was based on research and experimentation aimed at identifying functional methods for the analysis, diagnostics and restoration of Nagaur Fort protected by the Mehrangarh Museum Trust. The development trend of the Indian sub-continent offers huge opportunities for investments in protection and enhancement of local cultural heritage, whose potential has barely begun to be realized. The aim of the project was to promote the enhancement of Indian cultural heritage, focusing on technologies and methodologies in the field of conservation and restoration. In this scenario the maintenance of the good state of conservation of Nagaur Fort could be improved by a holistic approach toward the survey and monitoring.

This might be accomplished in a more efficient workforce, exploiting the advantages offered by new technologies, such as laser scanners, already known in India, but not yet functionally integrated in the processes of conservation.

The project has been aiming at the surveying of part of the fort, to test the instrument potential in acquisition of decorated architectural morphologies and related pathologies of degradation for conservation purposes.



Fig. 5: Point cloud analyses at Nagaur Fort (credit: DIAPReM centre)



The involvement of three Italian private companies, Geogrà srl, Digtarca Snc and Giancarlo Maselli Srl was a key factor for enabling the technology transfer: all the activities were carried out under the supervision of Indian staff and methodological seminars have been held during the campaign. Also a group of local conservator attended on field all the scheduled activities of the project in order to improve their awareness of these technologies. The survey campaign was carried out in ten days and allowed the collection of data on stones performance and state of conservation and 3D morphologies of part of the fort.

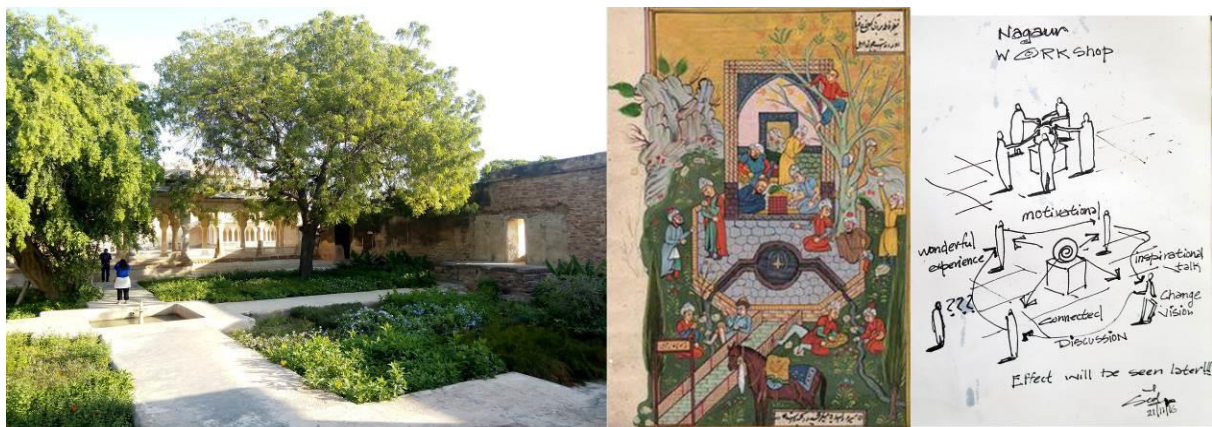
### 3.2. Helen Hamlyn workshops “Hands on”

Many workshops have been carried out with the support of important sponsorships: one of the most durable ones, renewed year by year, is called “Hand on workshop” financed by Helen Hamlyn Trust. Mrs Hamlyn after having visited the Nagaur fort decided to personally support the initiative funding part of the restoration works that were completed in 2012 and starting a series of workshops with students coming from all around the subcontinent and the world. Since then several Monument Conservation Workshop have been conducted by Prof Minakshi Jain at Nagaur, in association with the Mehrangarh Museum Trust and Helen Hamlyn Trust. Participants’ background was always various: they comes from architecture offices or from the very last years of their university path or they were PhD candidates and researchers taking the workshop as a part of their research activity.

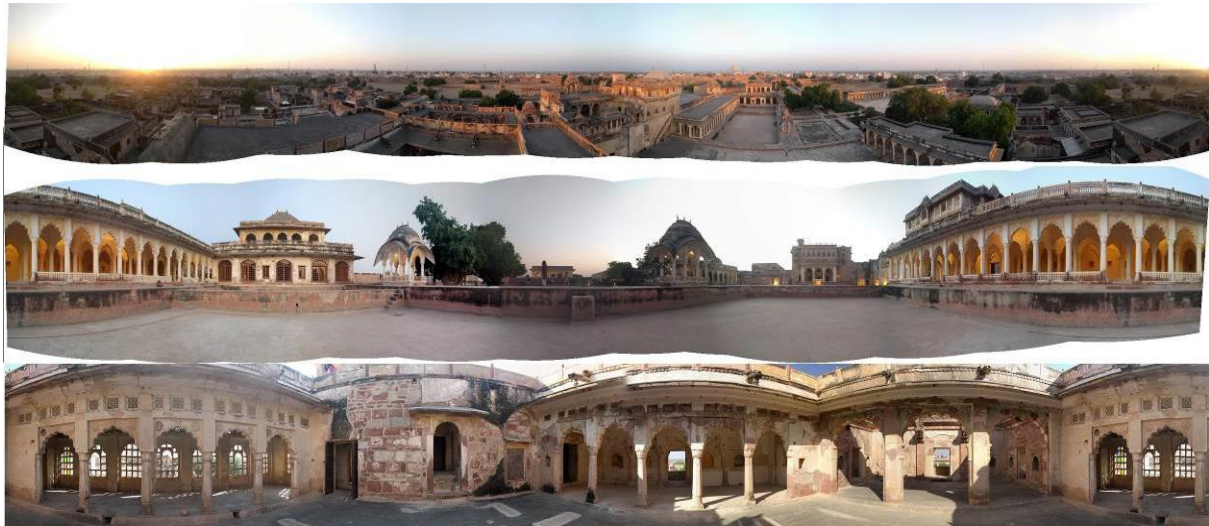
The aim of these workshops is to analyze the possibilities of the spaces of the fort thanks to the recognition of the ancient use, following the process of adaptive reuse. Participants are asked to create a visual analysis of the assigned area inside the fort and a bi-dimensional visualization of plans and elevations (taking into consideration green elements, fort-walls, etc). Then, by means of a SWOT analysis (developed within the boundaries of the fort not touching the surrounding areas) the possibilities and main problem of the different buildings are highlighted, and surveyed through a photographic campaign also in order to identify the potentials of each zone.

Over the past years a big part of the material representation the fort has been updated and implemented with the creation of booklets of each workshop: inside the booklet architects and the Trust staff tried to collect the majority of the drawings and the most important photos that illustrated the output of each workshop. During the last day of every workshop students were also asked to explain the project to different guests in a one day “workshop-in-workshop”: children from the nearby villages and schools were invited to take part to this initiative. In this way children were asked to express their perception of the fort in different ways; for instance during the workshop held in May 2017 the output were uncommonly various: from poems to songs, from drawings to dances. 17 children out of 37 decided to represent the fort as “how it should have been” in the ancient times.

During the restoration process a varieties of conservation and survey methodologies has been adopted: on one hand the adaptive reuse of some elements coming from other Forts, on the other hand the re-creation of the external gardens analysing the old paintings that were found during the restoration of one internal area. This started the interest towards the understanding of the initial shape of the gardens and the consequential typology of flowers and plants that were part of the fort landscape in ancient times, before the colonial period (KENAWY, 2016). The process needed a deep study of the significance of the drawings, because of the differences in the representative techniques used before the XVIII centuries however, through the comparison between different paintings the conservation architects found an interesting point of view on the problem on the preservation of green areas.



**Fig. 6:** recreation of Gardens through old drawings and (on the right) a sketch by students on aggregative points of the fort and functions (“Hands on Workshop”, November 2017)



**Fig. 7:** 360° view of Nagaur Fort developed in may 2017 by students of “Hands on Workshop”.

### 3.3. Digital tools for Heritage Enhancement

Some innovative representative solutions for Indian cultural heritage were tested in Nagaur Fort by the staff of the Department of Architecture at Ferrara University. During the past years, digital tools such as procedures of 360 degree photos with implementation of targets that reconnect directly to the information were developed. The 360 degree digital tour of the fort was created in the past and it was called “Eye on Nagaur”: this first experiment, focused the attention of the Trust and conservation architects on the new possibilities of visualization of the architecture aimed not only at documentation but also at developing an innovative way of enhancement of the cultural site.

The inclusion of relevant data within the immersive virtual tour environment can aid communication between a conservator and a building manager and facilitate informed diagnoses (NAPOLITANO et al., 2018). The proposal of a virtual tour led the staff of the University of Ferrara (DIAPReM Centre) towards its development in an unusual way: the aim was to create a virtual room inside the other forts of Maharaja. The main idea of the room was to create a sort of portal able to connect the various forts, which are very far each other, and make the people aware of the existence of the fort nets in Rajasthan. The sharing of these information could improve the knowledge on this rich mosaic of sculpture, temples, and painting that have gone towards the creation of one of the greatest civilizations of the world (HARLEY, 1986). This output can be improved with interactive settings, sound effects, captions, links to files in various format as pdf, jpg, etc. The water absent nowadays in the real environment of the fort could be virtually recreated in its original paths, pools, channels to visualize how the fort could look like in the past. Within the technological framework it is also important to highlight the elaboration of digital models by Ferrara University Architecture Department students. During a one week seminar held in Ferrara the basic survey drawing were taken as references and pictures of the fort construction were studied in order to identify the materials framework toward the creation of 3D models. Besides being a strong base for spatial research and study through these model were also possible to create a virtual reality (VR) model. If the representation needed is a 2D drawing (plan, section or elevation) the new functionalities offered by the software help the operator but are no longer enough for a complete description of the object. For this reason the attention is focused on the creation of parametric and non-parametric models inside the BIM process, in order to be able to assign all the collected information to the represented building (BARAZZETTI et al., 2016).

The key passages of the BIM creation were focused on: acquisition of building data, integration of other sources of information able to describe the built heritage, definition of reference geometries for architectural components, development/detailing of the building as 3D digital reconstruction, and implementation of instruments for the exploitation of the model between preservation and enhancement. The advantages associated to the approach proposed concern the flexibility of the adopted instruments, the quality of the results obtained in terms of precision and level of detail, and the possibility of communication between the developed product and other solutions oriented on the exploitation of the building through the model.

The final outputs highlighted a strong synergy between building management and valorisation approaches through the workflow. As identified by Simon Thurley, (THURLEY 2005), this data can be used by both local public bodies and technical professionals. The field of investigation is nowadays attracting students, teachers and professionals also in India, and it is increasing the awareness on the value of ancient architectures.



**Fig. 8:** 3D digital images of Nagaur Fort developed by second year students of the Department of Architecture at University of Ferrara during a specific seminar on Indian architecture.

#### 4. Objectives achieved

The research carried out along these 5 years had a good impact on the conservation and maintenance of historic architecture in India. This ranges from impact on culture, scientific production and business. Some impacts of the research are already clear, whereas in other cases it might take time, before the real value becomes apparent. It is not simple to predict the potential benefit or future outcomes, for sure there was an increase of fundamental understanding of the important role of maintenance programme through the use of advanced technologies.

For the first time laser scanning technique were applied to a Fort in India, increasing the curiosity toward this technology and also the involvement of local young researcher in this field of application. The cooperation with local bodies on activates such as the survey techniques development on historic Architecture has been crucial in order to start a common path of research that could possibly led to joint organization of courses for professionals.

Several scientific papers have already been shared with the public in international conferences in a strong cultural exchange between India and Italy. The continuous effort of activities such as conferences or simple lectures in both the countries has stressed the importance of the preservation of Indian cultural heritage (both at tangible and intangible level) and its valorisation. The collected databases were used by local institutions in order to understand the potentials of each technology and possible utilization for maintenance purposes.

In terms of business, local enterprises have better understood that cultural heritage could soon become a possible source of income: laser scanner producer have greatly helped and supported several activities o this research, and new clients have been attracted thanks to this dissemination. Probably the most important impact was indeed the capacity of new technologies to attract young students and researchers: they will be the future professionals in charge of the conservation of this huge legacy.

On the other hand we have to say that there were difficulties, due to local context constrains: flexibility was needed in order to solve problems and avoid mistakes. This has shown how the methodology could be probably applied also to other context, in other Asian countries. It is important to highlight that the aim of this research was to develop a methodology for maintenance and enhancement of Indian cultural heritage, so the purpose was not the implementation of new services provided by the University of Ferrara in this country.

#### 5. Conclusions

The real philosophy behind the implemented activities is the identification of local stakeholders able to learn and apply contemporary technique in this field. It is important to stress that even if it is not as accurate as traditional lidar, outputs from 3D dense point cloud generated by photo modelling can fill the gap between a very time-consuming activity and the traditional use of data in architectural office during the preliminary phases of a project. Probably photo modelling, especially in high tech countries such as India will be one of the next frontiers of the architectural, archaeological and urban, survey (DOCCI et al., 2011). On the other hand an high number of restoration projects have been carried out by foreign professionals in these countries. But the very particular character of Indian art is set within its cultural and religious milieu, raising important issues about the profound differences between Western and Indian ideas of beauty (MITTER, 2011). Western eye wouldn't be very useful for the conservation of Indian cultural heritage: there is a strong need of multinational projects able to improve the capacity of local professionals in heritage preservation and management field. Learning-by-doing

programmes could take advantage of the crucial mix of western conservation methodologies and local institutions knowledge. These two factors used at the same time could play a key role in cultural heritage preservation in many Asian countries thanks to the use of digital technologies.

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