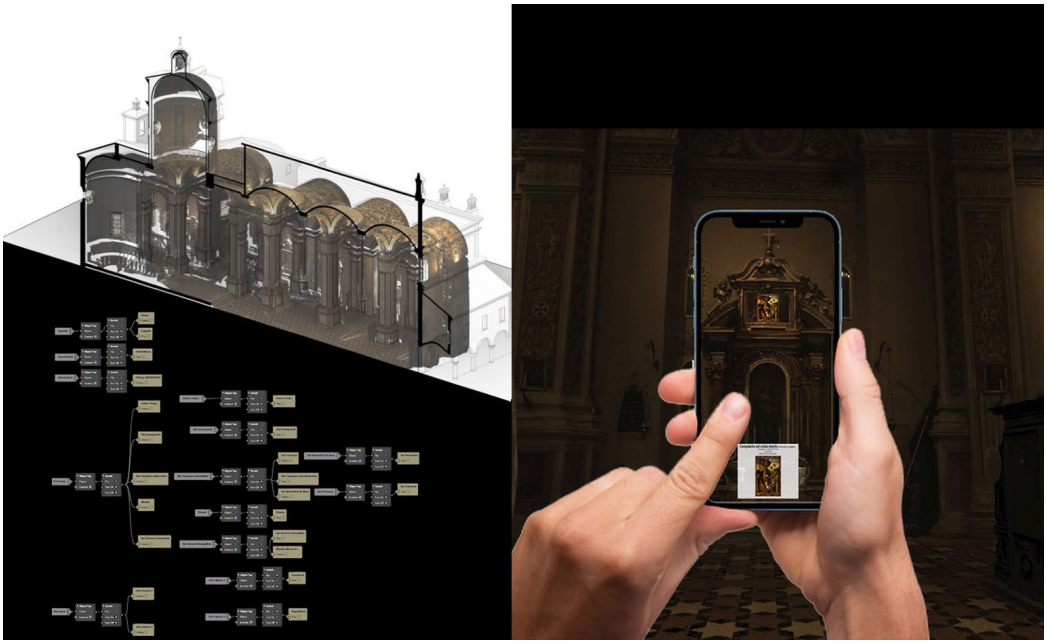
Data Structure for Cultural Heritage. Paintings from BIM to Social Media AR

Rachele A. Bernardello
Paolo Borin
Annalisa Tiengo

Abstract

This paper focuses on a process to communicate and enhance cultural heritage value. In this context, one of the main challenges is to combine its value with digital strategies and methods without losing information and increasing communication and public-private involvement. The paper proposes a methodology that uses BIM (Building Information Modeling) and CDE (Common Data Environment) concepts to build and organize information of paintings through connected databases, typically produced by multiple actors. A case study in San Nicolò in Carpi verifies its application. An Instagram profile has been created transferring data from BIM models to Spark AR Studio to demonstrate a method that creates an Augmented Reality application for cultural heritage, without the need of coding.

Keywords
AR - augmented reality, lowcost, cultural heritage, social network, value.



doi.org/10.3280/oa-845-c231

Cultural Heritage and Augmented Reality

This paper focuses on a process to communicate and enhance cultural heritage value. For the valorisation and a sustainable development in the context of cultural heritage, there is the need for a collaborative system of economy, space, culture, and social structures. For its promotion knowledge and strategic actions are fundamental concepts. In this regard, one of the main challenges is to combine cultural heritage's value with digital strategies and methods without losing information and increasing communication and public-private involvement. First, these processes use art and architectural historical knowledge, often paired with digital 3D modelling. It Is then crucial to propose a method that is socially and economically sustainable. The presented method involved BIM modeling, digital cultural heritage and Augmented Reality in order to obtain maximum diffusion and participation: with this aim social network opportunities have been explored.
One of the distinctive aspects of cultural contents is the relationship between the container, the architectural structure, and the content, such as paintings and sculptures. Moreover, the events that have transformed these relationships changed the original set and defined new configurations are opportunities for enhancing the value of cultural heritage. A common example is the painting moved to a different place, as in the church of San Nicolò in Carpi. The implementation of Augmented Reality enables new opportunities to describe scenarios that no longer exist and improve the users' experiences through their own devices.
In the first section of the paper, the authors explore significant experiences of AR application popularizing their cultural heritage artefacts through social networks.

State of the Art

The role of Augmented and Virtual Reality for cultural heritage and tourism has already been explored by scholars [Chung 2015; Yung 2019; Salerno 2019; Paliokas 2020]. The use of this technology is also popular in the industrial sector [Bottani 2019].
Significant applications of Augmented Reality in art museums highlight how the use of this technology is important to show contents related to cultural heritage (Fig. 1).
For instance, the temporary AR installation Reblink, promoted by the Art Gallery of Ontario in Toronto in collaboration with the artist Alex Mayhew, represents an interesting reference. It allows visitors to see some of the artist's works, as he has re-envisioned them. By using

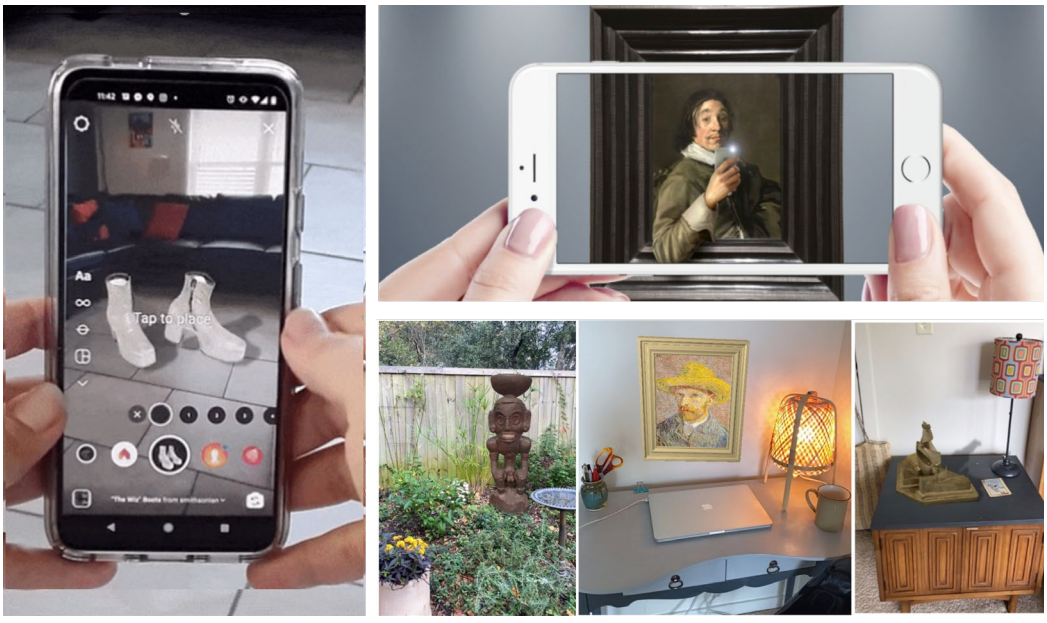


Fig. 1. example of AR and social network implementation for cultural heritge.

mobile devices, spectators can see the characters in contemporary and different environments. The artist is aware of this effect and wants to show spectators that mobile devices are flooding the user with an information overload. Mayhew's aim is to enhance his art through technology as an essential tool, rather than a distraction. Everything takes place inside the painting gallery, where visitors frame the artworks that act as image targets and enjoy watching the subjects in canvases while taking selfies, eating contemporary food or consulting their personal computer.
Other similar exhibitions confirm that Augmented Reality allows to reset space-time distances. In this regard, one of the most meaningful examples is the project *Do it for the 'gram: Exploring Smithsonian Augmented Reality on Instagram Stories* that shows the strength of the interaction between Augmented Reality and social networks. Thanks to the collaboration between five museums, the Digitalization Program Office and Facebook, Smithsonian created Augmented Reality effects for a selection some of its most iconic objects. Users can completely decontextualize all the objects available by placing them anywhere. Compared to a regular visit to the museum, this experience enables visitors to observe items closely and from different perspectives. The effects let people see the objects with the related information and acquire and share photos or videos through Instagram's tools. These objects, realized using Spark AR, are freely available and users can also share images and videos via Twitter and Facebook.
In November 2020, the Metropolitan Museum of Art launched a similar AR experience that brings famous objects and works of art in people's houses through the social network Instagram. The MET has designed three effects for the most used social media that allow everyone to approach the collection's famous objects. This unusual way to visit artworks overpasses certain limits: you can rotate the object to 360 degrees, observe it and zoom in. Besides observing the objects of interest, users can place them where they prefer, even inside their home, and then share them in their social profile.
Finally, in a context where the world of technology and digitalization discloses cultural content, the work of Olafur Eliasson is emblematic. The Covid-19 pandemic and the consequent restrictions have induced a stalemate that has affected all cultural activities. The artist replied by creating an app that recreates natural phenomena such as rainbows, suns, clouds, and rain in close spaces.

Information Exchanges, Actors and Roles in BIM to AR

The design of an Augmented Reality experience is a process that requires expertise and effort due to the use of specific software and the engagement of technical skills. Even though the organization of a large amount of heritage and effective investments in the so-called beauty economy is crucial in Italian economic and financial growth, in most cases fundings are not readily available to support this cost in Italy. In order to devise a low-cost process, it is helpful to think about alternatives that take into account open-source software and existing platforms. These platforms must be free, widely disseminated and predisposed to accommodate this type of technology. For this reason, social networks were considered the most effective mean to effectively disseminate such content. Above all, Instagram seems to be the most suitable platform, as it is based more on images and videos dissemination. Photo filtering, capturing and sharing contents with other contacts are basic actions on the Instagram environment. These features allow the public to appreciate information about the present heritage and visualize works preserved elsewhere or during their restoration (Fig. 2).
The creation of Instagram filters needs external platforms as Spark AR. The software offers a set of tools to create Augmented Reality applications without coding.The first step consists in choosing the "scene understanding", which is the method to align the virtual model to the real scene. Plane-tracker and target-tracker appear to be the most significant tools (Fig. 3). Following the logic behind the funcioning of any parent/child software, they are called "parent object" as spatial element that build the environment surrounding the content [Eastman 1999]. The fist method is based on a plane or a planar surface to locate child objects. In the

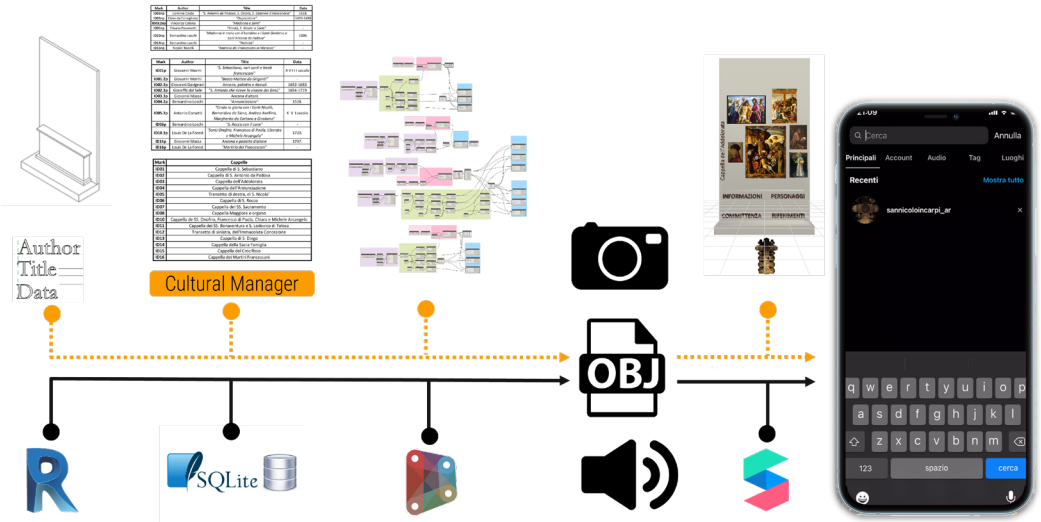


Fig. 2. Methodology process and software used.

Fig. 3 Reality tracking. Target tracker, the virtual scene is aligned to the image-tracker. Plane tracker, the virtual scene is aligned to a plane (i.e. the horizontal.

second one, the experience starts with recognising an image. The relationship between the tracker and the digital content visualisation represents a key point in the methodology. The actors involved in creating digital contents play a central role in the entire process. The proposed methodology here involves the cooperation between the information manager, the cultural manager (i.e. an art and/or architectural historian) and the 3D content manager without programming skills. Even if these figures could collapse in one person, the BIM approach helps us to highlight roles and responsibilities.

The cultural manager establishes which artefacts should be involved in AR applications, checks any contractual constraints regarding their distribution and produces textual information and references.

The information manager builds and populates the database, which summarises the information produced in the forms of texts, images, and documents. At the same time, the information manager creates a BIM model of the building, wich is the container that supports both necessary spatial reconstruction and data integration in the forms of attributes or links to other documentation. The information management may involve scripting through VPL environments to coordinate data among different file formats.

This approach highlights the importance of data structure around a BIM environment, providing the final user with a scalar set of information regarding deepening, filtering, and quantity. The typical concept derived from CDE (Common Data Environment) in BIM methodology represents a key point in the adopted method. The information manager's ability to structure interpretative historical transformation models helps to support content translation to the public.

The Communication of Paintings in San Nicolò in Carpi

The case study of this article is the church of San Nicolò in Carpi and its missing paintings. Thanks to the presence of the Observant Franciscan friars and the activities of the Pio family, the church has hosted important works of art during its history. It was commissioned by the nobles who sponsored the side chapels, and some paintings have a strong relationship with the spaces of the church. Unfortunately, they have been transferred or stolen, and they cannot be visible in their original configuration in terms of chapel placement and altar support.
The case study started from an analysis of the elements hosted in the church to investigate the existing artistic apparatus over time.
In particular, the analysis of the altars suggested that they were significantly transformed or replaced due to the Counter-Reformation. It was therefore essential to consult historical sources, collaborating with a cultural manager and an art/architectural historian to define a hypothetic structure.
A generic-shape altar was then modelled to replace the actual altars, that were not the original ones. This virtual object is parametric since it must adapt its dimensions to the multiple positions within the virtual space of the 4D BIM model of the church that represents the time passing. In addition, this object has a set of parameters designed to compile key information for its identification (Fig. 3). The shape of the altar model is offered by an altar being in a side chapel which, according to the sources, is the only one that currently has its original structure. Therefore, the use of simplified models is necessary not only to abstract their shape but also to optimize the AR solution in terms of file size.
A second step was to create a generic object to host the information about the work of art, such as the image of the painting and a property set that identifies author, title, year, and specific parameters for connection to other databases.
A VPL (Visual Programming Language) script allowed to write the identification parameters based on the values inserted in the database by the cultural manager. A second script then ensured the transformation of some of these parameters, such as author, title, date into graphic elements to place the information in the augmented 3D space.
The part of the BIM model is exported as an OBJ to prepare the virtual scene in Spark AR.

When using the Instagram platform, it is interesting to exploit its potential to fully convey other spatial information: social media play a fundamental role in the emotional involvement of the public. A specific feature of their use for cultural heritage is their ability to involve the user before, after and during the visit. Thanks to posts, a mosaic from the point cloud survey has been created. It allows the user to get oriented, understanding the geometries of the internal spaces of the church. It consists of a central nave and two minor ones, barrel-vaulted spaces, vaulted ceilings, and a central dome. The posts that produce the mosaic are divided

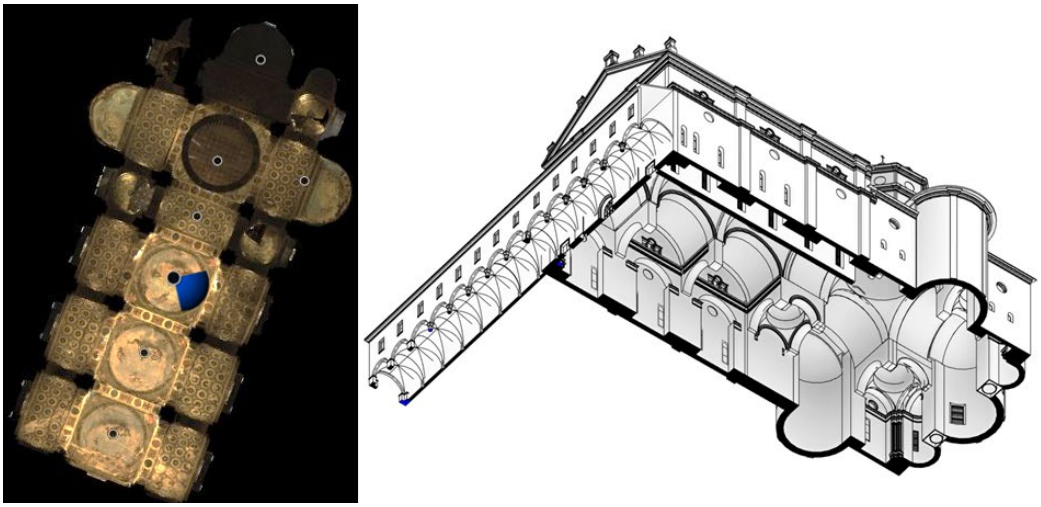


Fig. 4. BIM model as container of information.

into images and slideshows. The latter are in the points of interest where the fifteenth- and seventeenth-century altars were physically located. The others are simple pieces that complete the synoptic image.
The slideshows are composed of a. fragment of the mosaic; b. real-view image from point cloud; c. image of the painting in original place on the altar investigated.
The platform allows the manager to pair each publication with a caption in order to disseminate the main information regarding the painting.
The Instagram stories highlights section allows to fix the presence of the material acquired and published through history over time. In this way they are stable features of the augmented experiences, and the users will be able to learn how the application works and start their experience taking advantage of the Augmented Reality exhibition. The 24 hours Instagram stories can be then used for other scopes such as sharing users' posts or temporary events (Fig. 4).
During the design phase of the filters, the appropriate tracker was chosen among those proposed in the methodology. The first hypothesis was the use of a plane tracker. This type of reality tracking requires a clear horizontal line to recognize a plane or a surface. Since churches present imperfect lighting conditions, this method is unstable. Therefore, a solution based on target or image trackers is better suited to this case study because they could be both reproduced on illustrative panels and properly positioned close to the altar. This method is not as sensitive as the previous one, regarding lighting conditions.
With respect to the position of the digital object, the application does not allow a reference to the object tracker, so it is necessary to establish the exact point of the user. After that, the objects will appear in the correct position. In the present case study, the position is chosen frontally centered to the altar, at a five meters distance.
Each filter provided the following information: a. images of the painting represented on the altar, and of referenced paintings useful for the narratives; b. images of the location of the chapel you are visiting; c. three-dimensional text containing information about the author, title and date, owner, and other references.
The first tests showed a difficult narrative to read, confused by multiple objects within the scene. It was therefore necessary to use audio content. Every object that appears on the scene is a button that can be clicked to start playing the multimedia inserted by the information manager. With this system, the direct interaction with the particular object allows the observer to select the type of content he prefers to consult like basic information such as author, title and date, the description of the painting, the list of characters or other works related to the same author (Fig. 5).

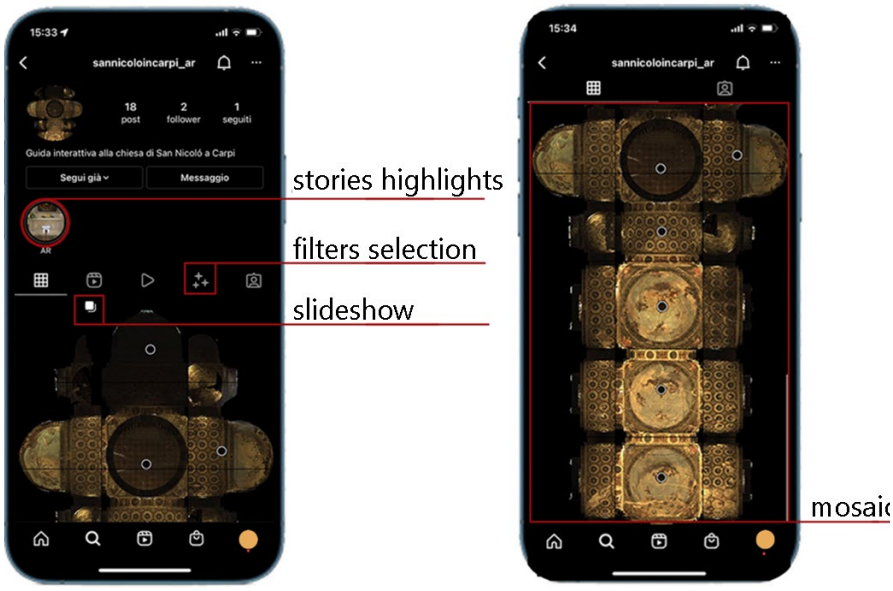


Fig. 5. Instagram first user's interface to access the Augmented Reality experience.

Chapel location
- Audio information

Characters
- Interactive labels
- Audio information

Other reference
- Images
- Audio information

Fig. 6. Example phases of the filters interaction.

Conclusion

The introduced study originates from the lack of models for the dissemination of historical-artistic contents, in reference to the enhancement of cultural heritage. The value of tangible and intangible cultural heritage has been generated by the information typically contained within a documentation from analogical and digital documents, images, maps, etc. Such documentation can often be related to specific location in the built environment. The relationship between the information and its spatial context increases the value of cultural dissemination. Because of this features, 3D digital models become important as they can be linked to different sources of information. In this sense, BIM modeling is a key point, as demonstrated in the present study.
After creating a work environment that can organize the data produced by multiple actors, and after placing it within the digital built environment, it is then possible to structure an information exchange that allows the integration of content with Augmented Reality. Due to economic availability of cultural organizations, the study tried to convey cultural content through Facebook's Spark AR platform. This allows to disseminate information through popular tools, facilitating the use and therefore the understanding of the contents.
The case study of the church of San Nicolò in Carpi has shown the possibility of reading some paintings no longer located in their original position through Augmented Reality. Moreover, since contents were produced by different actors, the example described above highlighted the importance of organizing the information flow.

References

Angei Fabio (2020). Quanto spende l'Italia in cultura?
https://osservatoriocpi.unicatt.it/cpi-archivio-studi-e-analisi-quanto-spende-l-italia-in-cultura (February 2022).

Bottani Eleonora, Vignali Giuseppe (2019). Augmented reality technology in the manufacturing industry: A review of the last decade. In *IISE Transactions*, 51(3), 2019, pp. 284-310.

Chung Namho, Han Heejeong, Joun Youhee (2015). Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site. In *Computers in Human Behavior*, 50, 2015, pp. 588-599.

Eastman Charles M. (1999). *Building Product Models*. Boca Raton: CRC Press.

Herigare-pro project (2021).
https://heritage-pro.eu/ (October 2021).

Interreg CENTRAL EUROPE Programme (2019). Documento D.T.1.5.4 Linee Guida per il coinvolgimento dei cittadini nei percorsi di valorizzazione dei beni appartenenti al patrimonio storico culturale. https://www.interreg-central.eu/Content.Node/Forget-Heritage/Italian.pdf (October 2021).

Ministero della cultura (2020). Piano della Performance 2020-2022. Conseguimento degli obiettivi specifici triennali e dei relativi obiettivi annuali contenuti nel Piano della performance 2020-2022.
https://media.beniculturali.it/mibac/files/boards/388a5474724a15af0ace7a40ab3301de/file_pdf/PERFORMANCE%20-%20ALL.%203.pdf (October 2021).

Nethex (2021). I numeri e gli asset del patrimonio culturale italiano, motore di sviluppo economico e finanziario con tanti settori collegati.
https://nethex.com/news/ (February 2022).

Salerno Rossella (2019). Digital technologies for "minor" cultural landscapes knowledge: sharing values in heritage and tourism perspective. In *Geospatial intelligence: Concepts, methodologies, tools, and applications*, 2019, pp. 1645-1670.

Paliokas Ioannis, Patenidis Athanasios, Mitsopoulou Eirini, Tsita Christina, Pehlivanides George, Karyati Elli, Tsafaras Spyros, Stathopoulos Evangelos, Kokkalas Alexandros, Diplaris Sotiris, Meditskos Georgios, Vrochidis Stefanos, Tasiopoulou Eleana, Riggas Christodoulos, Votis Konstantinos, Kompatsiaris Ioannis, Tzovaras Dimitrios (2020). A gamified augmented reality application for digital heritage and tourism. In *Applied Sciences*, 10(21), 2020, pp. 1-18.

Yung Ryan, Catheryn Khoo-Lattimore (2019). New realities: a systematic literature review on virtual reality and augmented reality in tourism research. In *Current Issues in Tourism*, 22(17), 2019, pp. 2056-2081.

Authors
Rachele A. Bernardello, Dept. of Civil, Environmental and Architectural Engineering, University of Padua, rachele.bernardello@dicea.unipd.it
Paolo Borin, Dept. of Civil, Environmental, Architectural Engineering and Mathematics, University of Brescia, paolo.borin@unibs.it
Annalisa Tiengo, Dept. of Civil, Environmental and Architectural Engineering, University of Padua, annalisa.tiengo@studenti.unipd.it

 Isbn 9788835141945