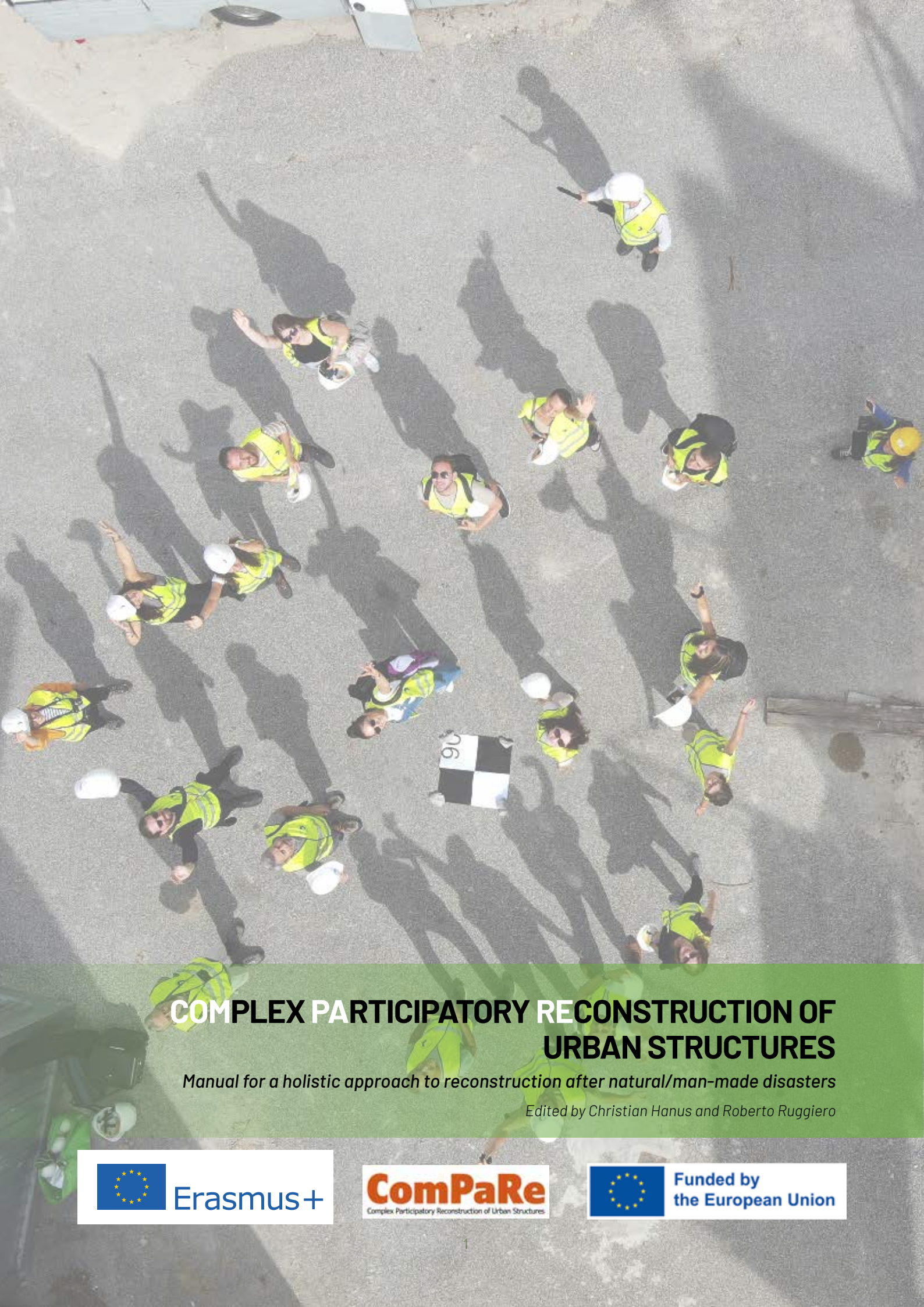




COMPLEX PARTICIPATORY RECONSTRUCTION OF URBAN STRUCTURES

Manual for a holistic approach to reconstruction after natural/man-made disasters

Edited by Christian Hanus and Roberto Ruggiero



Erasmus+

ComPaRe
Complex Participatory Reconstruction of Urban Structures



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Manual for a holistic approach to reconstruction after natural/man-made disasters

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**COMPLEX PARTICIPATORY RECONSTRUCTION OF
URBAN STRUCTURES**
Manual for a holistic approach to reconstruction after natural/man-made disasters



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COMPARE: A ROADMAP FOR A HOLISTIC APPROACH TO RECONSTRUCTION

Christian Hanus - University for Continuing Education (UWK), Krems (Austria)

Introduction

The reconstruction of urban structures following events of destruction—whether caused by natural disasters or human actions—remains, unfortunately, a topic of ongoing relevance. Its importance, both historically and in the present day, is illustrated by case studies from various parts of Europe. Knowledge and practices related to the handling of destruction and reconstruction differ significantly across the continent. [1]

However, it is often evident that the integration of collective knowledge about a city, along with various forms of intangible cultural heritage, is largely overlooked during reconstruction processes. The primary focus tends to lie on the immediate rebuilding of physical structures and infrastructure.

In this focus, it is frequently forgotten that every built structure originally emerged from defined needs, priorities, and purposes. No house, square, street, or piece of urban infrastructure was constructed arbitrarily; each served a specific, assigned function. The effort involved in the construction, design, and layout of these spaces was based on their functional, technical, economic, and cultural requirements and possibilities.

Equally overlooked is the fact that the population of a city develops, over generations, a unique and deeply rooted relationship with the urban environment and its buildings—through use, perception, and daily life. This intangible level includes local traditions, historical and cultural knowledge and awareness, religious practices, artisanal and culinary techniques, as well as artistic expressions such as music, literature, and theatre. The bearer of this entire intangible heritage is the local population. However, when living environments, infrastructure, or cultural objects are destroyed, people are often no longer able—or only able to a limited extent—to access and engage with that heritage. Yet, this intangible heritage is an essential and inseparable part of a city.

One key aspect of successful reconstruction lies in recognizing the population's role as knowledge holders of the city's character. Many buildings—particularly ordinary residential houses—are often inadequately documented. While structures such as churches, monasteries, town halls, palaces, or towers are typically well-documented due to their significance and visibility, simpler buildings may, in extreme cases, be represented only as outlines on a cadastral map. Even in the case of more prominent buildings, structural changes over time—both interior and exterior—are often poorly recorded.

This is where the local population can play a crucial role, filling in the gaps through their memories and personal archives. Old photographs, sketches, receipts for building materials, or drawings—often produced or preserved for other purposes—can provide valuable insights. A photo taken during a celebration may incidentally show a building in the background, offering clues for reconstruction.

In many respects, the local population is an invaluable source of knowledge for the reconstruction of urban structures. The central challenge, however, is how to access this knowledge, how to document it, and how to integrate it effectively into the reconstruction process. This is the key question at the heart of this project.

In practice, it has become clear that spoken dialogue alone—between planners, authorities, politicians, and affected communities—is of limited effectiveness. Verbal descriptions of buildings, their histories, or uses are often imprecise and open to interpretation. Technical terminology needed for precise documentation is frequently lacking. Additionally, differences in vocabulary, perception, and contextual understanding between the various stakeholders can hinder communication. Inadequate formats and inefficient structures further complicate the constructive and targeted integration of this knowledge into the reconstruction process.

For these reasons, the ComPaRe project—short for Complex Participatory Reconstruction of Urban Structures—has been launched. Co-financed by the ERASMUS+ programme of the European Union, the project is dedicated to developing tools and methods to support the reconstruction of historical urban centres destroyed by natural or human-made disasters. It also includes the development of a curriculum to train future reconstruction managers in the use of these approaches.

The project explores a variety of formats, methods, and instruments to retrieve, document, and incorporate the collective knowledge of local populations into planning processes. Visual and imaging techniques have proven especially useful. Similar to how police create composite sketches to identify individuals, visual reconstructions can be created for buildings based on descriptions from residents.

After the 1976 earthquake that devastated the Italian town of Venzone, the architect Roberto Pirzio-Biroli, who oversaw the reconstruction, developed drawings and visual representations based on descriptions provided by local residents. [2] These served as key sources of planning information and became an important reference point for the rebuilding process.

Today, this form of reconstructive dialogue with the population can be supported by advanced technologies: 3D scans using drones or multi-sensor robotic platforms, virtual spatial reconstructions, and interactive virtual environments. Planning-relevant information can be systematically processed using Building Information Modelling (BIM).

Equally important are participatory dialogue formats—such as community meetings, guided walks through damaged areas, or landscape-based workshops. Another key component of the project is the creation of a digital archive to collect photographs, plans, and documents. These can be catalogued spatially, temporally, and thematically, and made publicly accessible. The project also considers methods for large-scale contextualization of this information.

Reconstruction is not limited to restoring physical structures. It also encompasses the intangible dimensions of urban life—culture, community identity, and local economies. Destroyed places need not only physical rebuilding, but also the restoration of social and functional meaning. This highlights the close and dynamic relationship between material and immaterial structures.

By making the project results publicly available, the goal is to promote and refine a participatory approach to future reconstruction efforts. The active involvement of local communities—not only as sources of knowledge and cultural heritage, but as integral parts of the urban identity—aims to improve the quality of reconstruction outcomes and foster stronger identification with the rebuilt environment among residents, planners, authorities, and policymakers.

Nevertheless, it is to be hoped that as few situations as possible will arise in the future that require such reconstruction efforts.

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RETHINKING RECONSTRUCTION FOLLOWING A NATURAL OR MAN-MADE CATASTROPHE: HOLISTIC APPROACH AND PARTICIPATORY PROCESS AS KEY STRATEGIES

Roberto Ruggiero - School of Architecture and Design, University of Camerino (UNICAM) - Camerino (Italy)

«The struggle for a new form of housing (is) only one aspect of the larger struggle for new ways of living» [1]

Mies van der Rohe

Accident, disaster or catastrophe? A subtle (but not too subtle) difference

In everyday language, “disaster” and “catastrophe” are terms often used interchangeably, even if there is an important distinction between the two, especially concerning their impact scale and the level of sustained support needed for recovery. Generally, a catastrophe is a specific type of disaster that is so large. It exceeds a community's ability to cope. According to the Center for Disaster Philanthropy [2], a house fire affecting a single family might be classified as an accident, while a fire that engulfs several city blocks would be termed a disaster. In contrast, a wildfire that devastates multiple communities, prompting mass evacuations and necessitating extensive reconstruction, is classified as a catastrophe.

“Rebuilding” is always a complex, lengthy, and uncertain process. It involves various fields such as construction, engineering, and urban planning; it addresses a mix of social, anthropological, environmental, and psychological issues. This is even more dramatically true in contexts of man-made or natural events, such as wars, earthquakes, or floods. To approach this topic critically and thoughtfully, it is essential to define what a disaster or a catastrophe “ontologically” are, and what consequences, in the short and long terms, they imply. When distinguishing between the words “disaster” and “catastrophe,” it is helpful to focus on the latter due to its more significant consequences. Additionally, the etymology of “catastrophe” effectively highlights its impact on human systems in relation to these events.

Post-catastrophe emergency as “loss of balance”

In everyday language, we define “catastrophe” as «a sudden event that causes very great trouble or destruction» [3]. A more specific definition can be found in the term “καταστροφή,” which refers to the final act of classical Greek tragedy, where the story reaches its dramatic climax. The word is composed of κατά (down) and στρέφειν (to turn), and etymologically, it conveys the idea of an “overturning” in a dramatic sense (Tosco, 2019). To understand the scientific perspective on catastrophe, we can turn to the work of René Thom (1923-2002) in the 1960s. In his “Theory of Catastrophes,” the French mathematician describes a catastrophe as the result of a sudden and chaotic change in the forces acting on a particular system (Poston & Stewart, 2012). This indicates that a system, initially in equilibrium, becomes destabilized. Thom refers to this change as a “transition of the system,” moving from a state of stability to one of instability (Arnold, 1992).

When examining recent and past catastrophes - whether natural or man-made - we can observe two recurring characteristics in the instability generated within human systems. First, this instability is long-term, often taking several years for a stable equilibrium to be restored (Bobrowsky, 2013). Over time, the system moves toward a new equilibrium that cannot recreate the previous conditions (Belmonte, Scirocco, Wolf

2019, p. 13). During this period, as Thomas notes, the system remains unstable. In anthropogenic systems, this instability results in what is commonly defined as a “state of emergency”. It can manifest in various ways: the disruption of urban infrastructures caused by the destruction of built heritage, the loss of interpersonal relationships due to loss of life or displacement, disruption of economic stability owing to halted productive activities, and psychological imbalances stemming from the loss of homes and communities. All these phenomena arise from the alteration of the original balance within a human system, triggered by external factors, resulting in conditions categorized as emergencies, be they economic, social, or psychological. Therefore, the primary objective of any reconstruction process should be to restore a new, acceptable, and shared balance.

From this perspective, it is clear that catastrophe impacts two interconnected systems: the system of tangible assets, such as buildings and infrastructure, and the system of intangible assets, primarily social relations. Thus, the term “reconstruction” should not be understood simply as a physical rebuilding process; rather, it encompasses a broader and more complex approach that involves various stakeholders, starting with the affected communities, and requires multiple areas of expertise. Jiuping Xu and Yi Lu, both researchers in the field of disaster prevention at Sichuan University, emphasize that «*post-disaster reconstruction should not only restore the buildings and infrastructure but also account for economic development and natural environmental protection to improve the social-physical resilience*» (Xu, LU 2022, p. 32).

Civitas vs. Ubs. For a "human-centered" culture of reconstruction

A catastrophic event typically leads to two types of emergencies that arise in succession and differ in characteristics and duration. The first is an immediate and dramatic emergency that occurs at the moment of the disaster. The second is known as the “Second Emergency Phase” (S.E.P., Ruggiero et al., 2021), which can last for years or even decades, encompassing the period from the catastrophic event until the completion of the reconstruction process. The initial emergency response is usually managed by government agencies, such as the military and civil defence organizations, along with volunteer groups. This phase focuses on ensuring the safety of individuals, providing medical care, and supplying essential items such as tents for shelter and clothing [4]. The duration of the situation may vary, but generally, it is resolved within a few months. In the second case, known as S.E.P. (State of Emergency Phase), the emergency is less visible, yet its effects on populations can be very profound. Especially in scenarios where economic, political, logistical (such as accessibility to affected sites), and other factors contribute to a slow reconstruction process - like in Italy, where the average reconstruction time is about 15 to 20 years - this second phase often leads to a gradual unravelling of the relationships vital to a community. For instance, the abandonment of damaged buildings creates a second destructive phenomenon due to a lack of maintenance and care, exacerbated by weathering. When inhabitants are temporarily relocated, it can result in a “pulverization” of the community and a “fraying” of the social ties that are essential for its survival. Living in temporary and basic settlements for an extended period can lead to frustration and, at times, anger among residents. Finally, the uncertainty surrounding reconstruction timelines adds another critical factor that can have a demoralizing effect on affected populations.

In this Second Emergency Phase, we can compare the housing challenges faced by the population to those of migrants, refugees, and displaced persons who have increasingly arrived in Europe and the United States over the past few decades. In Italy, for example, the phenomenon of “long-term temporariness” characterizes the provisional centers where immigrants await the outcomes of their asylum claims [5]. Some individuals may remain in these centers for years. Virginia De Micco, a psychologist, psychiatrist, and anthropologist from GruppoPER (European Psychoanalysts for Refugees), notes that this prolonged state can lead to a “psychic condition” (De Micco, 2021). In these centers, as well as in temporary settlements following the catastrophic

[1] Magnago Lampugnani, V. (2010). *Die Stadt im 20. Jahrhundert: Visionen, Entwürfe, Gebautes*. Berlin: Verlag Klaus Wagenbach, p. 341.

[2] The Center for Disaster Philanthropy is an organization dedicated to funding social and philanthropic activities related to emergency housing following man-made or natural disasters and catastrophes.

[3] See the term “catastrophe” in the Cambridge Dictionary.

[4] On this topic, see: the UN Office for Disaster Risk Reduction document: *Sendai Framework for Disaster Risk Reduction 2015-2030 and the European Union document: Strengthening EU disaster prevention, preparedness and response*.

[5] On this topic, see: *Il sistema di accoglienza in Italia*, <https://unipd-centrodirittumani.it/it/temi/il-sistema-di-accoglienza-in-italia>.

event, the initial traumatic element is the significant disruption of everyday life. People find themselves thrust into a “new world” [6] where everything can seem “unknown and enigmatic.” As a result, they must reinterpret their surroundings to regain a sense of trust and familiarity. This is especially true regarding their ways of relating to others, expressing emotions, moving, and positioning themselves in space (De Micco, 2021, p. 46).

From this perspective, it can be argued that the trauma associated with a catastrophe stems more from the loss of the domus than from the physical destruction of a house. The term “domus” refers not only to a physical shelter but also to the Latin concept of a place where a sense of domesticity is nurtured. Similarly, it is not merely the loss of the urbs, which represents a collection of buildings, that generates feelings of uncertainty and precariousness - often making individuals perceive their environment as threatening and undesirable - but rather the loss of the civitas, understood as a community. According to psychoanalyst René Kaës, domus and civitas serve as the “metaphysic and meta-social guarantors” of a society (Kaës, 2006).

The time required to develop the reconstruction process is often labelled as a “time of uncertainty” for communities, and this phase carries significant strategic value. The duration of this period and how it is utilized are crucial not only for the community's well-being and livelihood but also for ensuring that the reconstruction process leads to a vibrant community that can derive benefits from it. History, even recent history, is filled with examples of reconstruction efforts that were completed long after the catastrophic event occurred [7]. For this reason, the wounds caused are often irreparable, as the definitive migration of inhabitants to other regions occurs due to the search for better work and security conditions. When this migration happens, the risk of rebuilding homes that no longer meet the actual needs of the community increases. As a result, reconstruction efforts may focus solely on physical structures rather than prioritizing a human-centred approach.

The social paradigm of reconstruction

Using seismic events as a case study, various popular systems for measuring earthquake magnitude take into account different parameters. The *Richter Scale*, which is the most widely recognized method, quantifies the amount of energy released during an earthquake. Over the years, different agencies have developed their scales based on various criteria.

For instance, the Mercalli Intensity Scale assesses the intensity of an earthquake based on its observable effects on buildings and the Earth's surface, while the Japanese *Shindo Intensity Scale* focuses on the duration of the shaking

The impact of an earthquake or other types of disasters cannot be assessed solely by the energy released or the physical damage to properties. There are additional indicators that help gauge the more subtle, yet potentially more challenging, aspects of damage and, specifically, how these events affect the “social functioning” of a community and the well-being of its individuals.

For example, Post-Traumatic Stress Disorder (PTSD) is a mental health condition triggered by experiencing or witnessing traumatic events, which can include natural disasters, serious accidents, terrorist acts, war, rape, or other violent personal assaults. Another interesting measure is the Waffle House Index, introduced in 2011 by Craig Fugate. This informal indicator estimates the level of assistance required for disaster recovery. It is based on whether Waffle House, a fast-food chain known for remaining open during extreme events, is operating its full menu, offering limited items, or is closed altogether (Yun, 2023).

The varying damage assessment systems that arise from earthquakes (and other types of disasters) illustrate that reconstruction is a multi-level process involving both urban and social regeneration. This

[6] The term “new world” is here used thinking to the Emanuele Crialese’s movie *Nuovo Mondo* (2015), which depicts the first wave of Italian migration to the United States in the 1920s.

[7] In Italy, for instance, the reconstruction of the towns affected by the 2016 Central Italy Earthquake is still a largely incomplete process. According to the *Secondo Rapporto sullo stato della Ricostruzione (Second State of Reconstruction Report)* presented in May 2024, still 11.182 households are in precarious housing conditions. (source: Presidenza del Consiglio dei Ministri - <https://sisma2016.gov.it/2024/07/10/sisma-2016-ricostruzione-e-riparazione-socioeconomica-fanno-segnare-il-cambio-di-passo-del-centro-italia-stretto-tra-crisi-demografica-e-climatica/>).

process requires an interdisciplinary approach. Without a “social infrastructure” to guide efforts, any reconstruction strategy will lack meaning. We can refer to this concept as the “social paradigm” of reconstruction (Fu 2023). This paradigm has its roots in two influential studies from the early 20th century. In 1917, Samuel Henry Prince examined the Halifax Explosion and explored how catastrophes induce social change at the family, neighbourhood, and city levels. Then, in 1932, Lowell Juilliard Carr redefined disasters as a category of social change, thereby opening the discussion on reconstruction to the field of sociology. The relevance of the social paradigm continues today, as supported by numerous studies in recent years (Barenstein and Leeman, 2012; Farnaz Arefian et al., 2021).

Tools and thoughts

Although disasters are generally unwanted events, they can create opportunities to reevaluate and revitalize affected territories and their communities. For example, the great Kobe earthquake of 1995 led to the discovery of new hot springs, which in turn fostered the development of tourist accommodations. Similarly, the 2008 earthquake in Sichuan, China, improved soil quality, resulting in increased rice and corn production (Millevoi 2023, p. 50). Additionally, seismically active areas often feature fertile soils, abundant marine life, and notable geographical formations such as islands, peninsulas, and mountain ranges, which can attract human settlements. This is why «*the Pacific Ring of Fire, where 90% of the world's earthquakes occur, is home to some of the most densely populated cities and urban regions, including those in Japan, China, Taiwan, the Philip- pines, Indonesia, California, Mexico, and Latin America*» (Fu 2023, p. 8). [8]

To realise this opportunity, adequate planning resources must be deployed. Re-designing territories and communities is a complex challenge that requires creativity. Unfortunately, the reconstruction debate often reflects a kind of “atrophy of the imaginary” (Pacini 2022), becoming overly focused on technical and managerial aspects. While these elements are essential, they do not encompass all the issues involved in the reconstruction process, particularly the social and welfare-related concerns (Deserai, Crow, Albright, 2021). This more comprehensive approach is especially important in contexts that were already fragile before the catastrophic event, such as areas marked by poverty, inaccessibility, or low-density housing. These situations demand a more radical re-engineering of socio-economic conditions.

If rebuilding also entails redesigning communities and the spaces they inhabit, the effectiveness and success of this process depend on the community's active participation. Indeed, the community itself plays a dual role: it serves as both the end user of the reconstruction process and the guardian of “memory,” which embodies the unique cultural identity of each human settlement. This cultural identity is often at risk of being erased by catastrophes (Deserai, Crow, Albright, 2021).

A holistic and participatory approach: reconstruction as an “open work”

To cultivate a “reconstruction design culture” grounded in the principles of multiscalarity and interdisciplinarity, it is essential to develop holistic approaches [9] that begin with understanding the relationships and interdependencies between tangible and intangible assets disrupted by catastrophic events. In his book *Opera aperta* (Eco, 2016), the Italian novelist and cultural critic Umberto Eco examines the concept of “open work” in artistic production. For Eco, an open work allows for multiple interpretations shaped by the reader, while a “closed work” leads the reader to a singular interpretation. [10]. As a paradigmatic example, Eco cites Scambi, an electronic music composition created by the Belgian composer Henri Pousseur in 1957.

[8] The Pacific Ring of Fire is a horseshoe-shaped area in the Pacific Ocean known for its high seismic and volcanic activity. It's home to about 75% of the world's active and dormant volcanoes and experiences around 90% of the world's earthquakes

[9] The term “holistic” is derived from the concept of “holism,” a biological theory developed in the 1920s. This theory suggests that the parts of a whole are intimately interconnected, meaning they cannot exist independently or be fully understood without considering the whole. As a result, the whole is viewed as greater than the sum of its individual parts. Holism is commonly applied to various fields, including mental states, language, and ecology.

[10] On this topic, see: Dack, J. (2009) “The electroacoustic music of Henri Pousseur and the open form”, in Heile, B. (ed.) *The modernist legacy: essays on new music*, Aldershot Ashgate. pp. 177-188.

Eco refers to Scambi as an “open work” because the user can organize and structure the musical discourse. Unlike traditional operas, where the audience passively experiences the music, in the work of Pousseur the listener becomes an active participant in the musical process, influencing its perception and interpretation. In other words, he collaborates in “creating the opera” (Eco 2016).

The concept of “open work” should be applied to reconstruction efforts. Whether following the philosophy of “as it was, where it was” [11] or opting for relocated reconstruction - as seen in the case of Gibellina, in Italy (1968) [12]- it is crucial to involve the local community as the primary territorial actor. This involvement is essential for developing reconstruction processes focused on the community's characteristics, resources, identity, and specific territorial assets (Pierantoni, Sargolini 2020). Neglecting this aspect can lead to the reconstruction of structures and artifacts that do not fit the changed socio-economic conditions or are based on settlement principles that are alien to the local housing culture.

Since reconstruction can be viewed as an open work, it has the potential to inspire effective actions rather than simply serving as rhetorical principles (Cooke, Kothari, 2001).

The implementation of this approach often clashes with the policies usually employed in reconstruction, which tend to view populations as passive participants in the process. It is indeed challenging to merge multiscale, bottom-up strategies with the predominantly top-down methods that are typical in public administration. In any case, this approach requires suitable tools to enable communities to «share resources (both tangible, such as money or materials, and intangible, such as information or knowledge) and create new human relationships, thereby increasing the so-called social capital within the community itself» (Talia, 2014 p. 95). In this perspective, this book provides critical views and practical tools for culturally framing post-disaster and post-catastrophe reconstruction using a holistic, multilevel, and participatory approach.

[11] The question of “as it was, where it was” became prominent after the collapse of the *Campanile of St. Mark's Basilica* in Venice in 1902. A heated debate ensued between those who wanted to rebuild it “as it was, where it was” (the Venetians) and those who advocated for “where it was, but not as it was” (the Austrian architects of the time, including Otto Wagner). This issue often resurfaces following events that impact important urban or environmental contexts.

[12] Gibellina, located in the Belice region of Sicily, was devastated by an earthquake in 1968. The town was rebuilt a few kilometres from its original location, while the original site was transformed into a work of art by the Italian artist Alberto Burri. Completed in 1989, Burri's creation features a concrete surface that mimics the shapes of the town's ruins, forming a large cretto that symbolizes memory and destruction.

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“LEARNING RECONSTRUCTION” FROM A HOLISTIC PERSPECTIVE. CONCEPT AND STRUCTURE OF THE MANUAL.

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Writing a manual in the digital age

Digital culture has transformed many rules and habits in education, challenging the long-standing dominance of the “book” as an essential learning tool. In recent years, new educational resources, particularly hypertexts and tutorials, have emerged and, in some cases, surpassed traditional books' popularity.

Hypertext is a digital text system that organizes and presents information through links (hyperlinks). Hyperlinks can connect to other sections within the same document, different documents, or even external web pages. This interactivity enables readers to explore related information in a non-sequential manner rather than following a fixed order from beginning to end, which is typical of traditional printed books.

In contrast, a tutorial is a digital resource that provides step-by-step instructions or explanations to help users understand and master specific concepts or skills. Tutorials utilize multimedia elements such as text, images, videos, and interactive components to enhance engagement and comprehension. They can be applied to various subjects, from software applications to complex academic topics. Considering the significant impact of these tools in educational practice, creating a manual in the form of a traditional book may seem unusual, even if it is motivated by important and thoughtful reasons.

Complex Participatory Reconstruction of Urban Structures is a manual for a holistic approach to reconstruction following natural or man-made disasters. It is available in both electronic (PDF) and printed formats. It is structured like a traditional book, complete with an index and a sequence of chapters. Nevertheless, it is a versatile tool that can also be read non-linearly, as it includes contributions that address various topics from diverse perspectives and areas of expertise. Each chapter is both autonomous and, at the same time, interconnected with the other chapters. Thus, linear reading is not necessary. The manual is designed for easy navigation, allowing users to find the information they need effortlessly. Like a true hypertext, one can “jump” from one section to another or focus solely on a specific part.

Despite the flexible ways to engage with the content, this remains a traditional book intended for print. The authors made a deliberate choice to offer the manual in a printed version, viewing it as an added value. Physical books, indeed, provide a sensory experience that digital formats often lack. Holding a book, flipping through pages, and making notes in the margins can be a gratifying and engaging experience for many users. This tangibility can enhance comprehension and retention of information, making paper manuals a preferred choice for certain audiences. Furthermore, accessibility is a key advantage of paper manuals. Unlike digital documents, which require electronic devices and internet connectivity, paper manuals can be accessed anytime, anywhere, and finding a place in a library or bookstore, which still today are those containers of culture and knowledge that offer a tangible and sensory-rich experience that virtual libraries cannot replicate.

Holistic approach vs. problem-solving culture

We live in an era defined by digital innovation and increasingly powerful, accessible tools resulting from advancements in technology. This phenomenon has significantly changed many of our habits across nearly all areas of human activity, including scientific research and learning. In a world facing political, environmental, and social crises, alongside the emergence of powerful technological tools (Verdolini, 2023), a scientific culture is developing that emphasizes the urgency of providing effective and rapid solutions to these pressing issues. We can refer to this culture as a "problem-solving" approach, in contrast to a "problem-setting" approach (Arieli, Sagiv, 2018). Understanding the distinction between these two methods in research practice is crucial for comprehending the dynamics of scientific inquiry.

If problem-solving prioritizes results-driven approaches (typical of STEM disciplines—Science, Technology, Engineering, and Mathematics), problem-setting focuses on holistic, interdisciplinary approaches that consider the broader context and interconnectedness of issues. The holistic approach seeks to understand

the bigger picture by examining the relationships and interactions between various elements rather than isolating them (Miseliunaite et al., 2022). For example, in healthcare, a holistic approach looks at a patient's overall well-being, considering physical, mental, emotional, and social factors instead of concentrating solely on specific symptoms or conditions.

Even though it is clear that both specialized and holistic approaches are complementary and essential for advancing science and effectively addressing complex challenges (Calabrese et al., 2022), we are currently living in a "poly-crisis" era. This environment, coupled with the capabilities of modern digital technologies—particularly artificial intelligence—has provided us with a powerful new framework for problem-solving. Today, many research and educational programs emphasize specialized methodologies, focusing mainly on the development of tools, leaving less room for the holistic approaches necessary for critically interpreting problems. This trend might lead some to perceive holistic approaches as outdated; however, that is not the case. In this time of crisis-induced stress and rapid technological innovation, prioritizing a holistic approach and fostering a scientific and learning culture that values questioning over providing immediate answers is more important than ever.

The advent of artificial intelligence, which Mario Carpo terms the “post-digital age” (Carpo, 2023), underscores the urgency of adopting this method. Many people fear that increased reliance on AI-driven systems may erode human skills and decision-making abilities. As machines take over complex tasks, there is a risk that individuals may become overly dependent on technology, losing their capacity for critical thinking and independent problem-solving. The current trend to seek answers from generative AI can inhibit our ability to ask the right questions, which is crucial for developing effective solutions. Maria Chiara Carrozza, an Italian physicist, engineer, and former University Minister, emphasizes the importance of "thinking disruptively today." She advocates for striving towards "divergent answers" rather than relying solely on the "convergent responses" generated by models like ChatGPT, which rely on past knowledge (Prencipe, Sideri, 2023, p. 9). In summary, a holistic approach in any field of human endeavor should prioritize the formulation of divergent questions before creating the tools and methodologies needed to address the challenges we face.

The manual structure. Storytelling, methods and tools as learning strategies

This manual is designed to engage readers and support educational journeys by integrating the two approaches (holistic and problem-solving). It encourages the development of critical thinking regarding the topic of reconstruction, placing affected communities at the forefront of this reflection. Additionally, it provides a variety of tools and resources that equip readers with practical skills to operate effectively in reconstruction scenarios. By integrating the holistic approach's emphasis on interconnectedness with the tool culture's focus on efficiency, individuals and organizations can navigate the complexities of the digital age more effectively. This balanced perspective allows for innovative solutions that are both efficient and sustainable, ultimately leading to greater overall success.

In practice, the manual consists of two interconnected sections: Tales of reconstruction and Methods and Tools. Tales of reconstruction features essays recounting experiences of reconstruction following catastrophic events. This section uses “storytelling” as a tool for reading and critically interpreting catastrophic events and reconstruction processes.

In the realm of education, storytelling has emerged as a powerful strategy that transcends traditional teaching methods. It can be very useful in fostering a holistic approach to problems. By weaving narratives that captivate and engage students, educators can foster a deeper understanding and retention of knowledge. At its core, storytelling taps into the fundamental human experience of sharing and receiving stories. From ancient myths to modern novels, stories have served as a primary means of communication, helping people make sense of the world and their place in it.

In this section, different kind of disaster (earthquakes, floods and other man-made disasters) and the subsequent reconstruction processes are told. Those “stories” belong to different geographic areas, mainly from the European countries involved in the Compare project. They are presented and discussed following

the same trail: the disaster is described with its specific characteristics (type, intensity, area involved, etc.) and then critically examined about the reconstruction approach used, the relationship between the reconstruction process and the affected populations, and the outcomes achieved. Since this manual is intended for educational use, teachers can leverage this approach to enhance research and encourage students to engage in their storytelling based on other case studies. This first section is further divided into two subsections: *Tales from the Contemporary*, which recounts recent reconstruction experiences from the last few decades, and *Tales from the Past*, which examines historical examples. In the first, contemporary stories of disaster/reconstruction are authored by researchers from various universities involved in the project, while *Tales from the Past* is entirely developed by Masaryk University (MUNI) of Brno (Czech Republic, Department of Art History. In these sub-section, historical narratives are derived not from firsthand experiences of the disasters, but from how figurative arts have depicted both natural and human-made disasters over time, particularly during the Middle Ages. In this approach, storytelling is not only a tool for critical reading but also highlights figurative arts as a “lens” for interpreting facts related to past disasters and reconstruction.

The second section, *Methods and Tools*, mainly defines operational processes and methodologies derived from field experiences developed during the Compare project. Some of those methods have been tested by partner universities in different contexts. In line with the previously mentioned "problem solving" approach, this part of the manual presents tools in their functional dimensions to support innovative and participatory processes to reconstruction. This part is also divided into two sub-sections:

Theoretical Framework, which explains some methodological aspects of a holistic and participatory approach to reconstruction, and *Applications*, which presents processes, methods, and tools illustrated through field experiences and experiments conducted during the project.

The volume also includes an introductory section (of which this essay is a part) that outlines the objectives and context of the work, as well as a concluding section written by Prof. Christian Hanus, the project coordinator, who summarizes the findings from this rich and diverse compilation.

Finally, *Complex Participatory Reconstruction of Urban Structures* (Compare) serves not only as a manual for a holistic approach to reconstruction after natural or human-made disasters but also as a comprehensive work by multiple authors, resulting from field research and experimentation. It aims to promote a culture of reconstruction based on holism and participation, advocating for a methodology that values critical analysis of events as essential for initiating effective processes and implementing appropriate methodologies.

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TALES OF RECONSTRUCTION

Section

1

Tales from the past

ABSTRACT

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The destruction of a city – whether partial or total – has been a traumatizing yet recurring event throughout history. Natural disasters such as earthquakes, fires and floods, as well as war violence, are often responsible for these dramatic occurrences. Looking at the past, it becomes evident that if destruction comes in many forms, so does reconstruction - this act is often as practical as it is political or economic. However, a destroyed city is also like a wound that rips at the surviving community's collective identity. Reconstruction can then become an act of collective therapy. Conversely, a city left to neglect remains a memento of unhealed suffering. This chapter aims to explore how the trauma of destruction was dealt with by past cultures. Its starting point will be a methodological reflection on how a historical discipline – in this case, art history - can help deal with various contemporary disasters. This will then be followed by an analysis of four case studies from firstly, the late antique world, through to Bologna and Central Europe in the 16th century, and lastly, Ani, the historic capital of Armenia. By no means are the selected case studies intended to offer a representative overview. Instead, their purpose is to show as many examples as possible of devastation and corresponding solutions that could be useful for ongoing reflection.

CITIES POST-CATASTROPHE AND LANDSCAPES AS SITES OF CULTURAL AGENCY

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ComPaRe: Art History in the Post-Catastrophic City - Elisabetta Scirocco - <https://youtu.be/CiP68ZhSi6I>

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Introduction

Natural disasters are important agents in the history, present, and future of Italian cities and landscapes. In only the past fifteen years, destructive earthquakes hit the city and surroundings of L'Aquila (2009), the Emilia region (2012), and a vast area of Central Italy (2016-2017). These events have dramatically and significantly affected cultural heritage. While contemporary architecture must adhere to construction principles that can withstand earthquakes, with historic buildings it is only possible to limit the most serious damage with preventative conservation efforts.

Even though Italy can count on a long tradition of the theory and practice of urban, architectural, and artistic conservation and restoration, every strong earthquake is catastrophic and creates scenarios of uncertainty.

How can one approach healing the disaggregation, the dispersion, and the de-localization of communities? What role does cultural heritage play in this process of resilience? In planning the future, what, how, and how much reconstruction is needed? How can one balance the image of the past and the needs of contemporaneity?

These are just a few among the many questions that institutions, specialists, and the affected communities face after such disasters.

Why Do We Need Historical Awareness to Face Disasters?

It is often claimed that we cannot understand the present or plan for the future without an awareness of history. This statement seems all the more true in the case of disastrous events that have happened so many times in the past, and that we are sure will happen again in the future – even if we cannot predict them. The Italian peninsula is a territory with one of the highest levels of seismic activity in Europe; circa 5.000 inhabited centers have a history of one or more devastating earthquakes.

L'Aquila, a city founded in the 13th century and severely damaged by several earthquakes throughout its history, is currently completing its ninth extensive reconstruction after the 2009 catastrophe. The totality of its cultural heritage – 100% – was damaged and the time for reconstruction was estimated to be around 20 years. The guiding principle for the reconstruction in L'Aquila can be summarized in the phrase “how it was, where it was” (“com’era, dov’era”) (Fig. 1).

Towns and villages in the Belice area of Sicily hit by a strong earthquake in 1968 had different fates: some of them were abandoned forever, others rebuilt in the same place, and still others re-founded elsewhere. The most significant case is Gibellina. The old village, almost entirely reduced to rubble, was destined for abandonment but later transformed by artist Alberto Burri into a spectacular work of land art, the Grande Cretto. Urban planners, architects, and artists were called to design the spaces, buildings, and street furniture of a town called New Gibellina (Gibellina Nuova), 19 km away from the original village. (Fig. 2).

This utopian project adopted contemporary art to express citizens’ resilience and progress. The result, however, was controversial and the population’s feelings towards the spaces and monuments of new Gibellina veered towards alienation, as socio-anthropological studies have revealed. On the contrary, in Friuli, the inhabitants of Venzone, hit by a severe earthquake a few years later (1976), immediately demanded the rebuilding of the town and participated in the reconstruction by collecting stones and architectural fragments of historic monuments (like the cathedral).



Fig. 1 - L'Aquila, January 2019 (©Antonio Di Cecco).



Fig. 2. Left: Ruins and rubbles of Gibellina Vecchia transformed into Alberto Burri's Grande Cretto, 1985 (source: web) Right: Gibellina Nuova, Franco Purini and Laura Thermes' Sistema delle piazze (1982-1990) (©Antonio Di Cecco).

Some towns in the Emilia region damaged by earthquakes in 2012 saw the systematic deterioration of historic monuments, if not their destruction. During the 2016-2017 seismic sequence in Central Italy, the delay in post-disaster interventions – partly due to the vast territory affected – caused the decay and loss of numerous historic monuments and works of art. Various decisions have been made concerning the reconstruction of historic towns and villages like Amatrice, Accumoli, Castelluccio di Norcia, amongst others - a process which has not yet come to an end.

Historical perspective makes it possible to analyze the decisions of post-seismic interventions and their long-term effects, in order to critically evaluate present and future courses of action.

What Role Can Art History Play in Post-Catastrophe Scenarios?

Art History, by its very nature, tends to be transdisciplinary, and in a post-catastrophe scenario, such an approach can be beneficial whilst addressing the challenges that put works of art, urban spaces, and historic landscapes at risk. Interventions after natural disasters require multiple areas of expertise and involve several disciplines: Art History, Archaeology, Architecture, Urban Planning, and Conservation. Moreover, it is crucial to recognize the social implications of cultural heritage after a disaster (eg. regarding spaces, monuments, and artworks with devotional functions or connected to civic identity) and to incorporate anthropological perspective while planning and carrying out a reconstruction.

Art historians should directly be involved in the aftermath of a catastrophe, not only as experts in the preservation and conservation of cultural heritage, but also as researchers that can contribute to debates, discussions, and decision-making regarding the future. For instance:

- participating in debates about how to deal with contemporary post-disaster scenarios with background knowledge coming from historical research;
- critically analyzing the media culture of disasters and its pitfalls;
- promoting initiatives to balance the media and exhibition overexposure of some works that become “icons of the catastrophe”, and the long invisibility of the majority of artworks recovered in storage after a disaster;
- reconciling the technical needs of restorations with broader historical, cultural, and anthropological perspectives (i.e. questions concerning the preservation of memory and identity);
- curating art-historical and artistic projects to understand and react to the chaotic reality of disasters.

How can art historical research contribute to creating sites of cultural agency?

As part of the project *Storia dell'arte e catastrofi: L'Italia sismica* (Kunsthistorisches Institut in Florenz – Max-Planck-Institut, 2015-today), transdisciplinary research groups have worked in this direction. They have mapped, documented, and interpreted cities and sites post-catastrophe, adopting an ethnographic methodology and involving local communities and specialists from different fields.

On-site research and photographic projects in L'Aquila and Emilia, for example, have investigated the relationships between space, memory, and identity, focusing on the meanings acquired by sites, monuments, and works of art after disasters (Fig. 3). Another case study is concerned with the stratifications of the Apennine landscape between Abruzzo and Lazio, as impacted by the earthquakes of the past 60 years. The result is a series of photographs by the artist Antonio Di Cecco and thematic maps by architect Giovanna Ceniccola of the pre- and post-catastrophe settlements (Fig. 4).

Photography is one of the main mediums employed for post-disaster representation and narrative construction. Creating a dialogue between contemporary photography's visual investigation into post-earthquake Italian landscapes and historical photographs related to natural disasters (eg. volcanic eruptions, landslides, floods, earthquakes) allowed for a reflection on the levels of representation and sedimentation of natural catastrophes in places and in cultural memory (Fig. 5).



Fig. 3. Antonio Di Cecco, *Mirabello, 4 aprile 2016, 'Postcard'* (2017). The series *Abitare il Tempo. Cartoline dall'Emilia* by photographer Antonio Di Cecco resulted from on-field research carried on by the transdisciplinary group *Topologie del terremoto* (KHI Florenz, 2016) in some cities and towns in the Emilia region struck by earthquakes in 2012.



check the caption

Fig. 4. Giovanna Ceniccola, *Map with the historical center of Verchiano* [above], *near Foligno, and the «temporary village» built after the 1997 earthquake* [below]. Architect Giovanna Ceniccola has conducted field research with photographer Antonio Di Cecco for the project *Appennino sismico* (KHI Florenz 2018-2020).



Fig. 5. Above: Venzone, Piazza del Municipio, photographic object (ca. 1900-1930) with manuscript annotations referred to war (1944) and seismic damages (1976), from the Photoarchive of the Kunsthistorisches Institut in Florenz – MPI (inv. KHI no. 122452).

Below: Antonio Di Cecco, *San Felice sul Panaro, Temporary church and town hall*, April 2016. The two photographs are part of the exhibition *Photography and Catastrophe* (KHI Florenz, online, 2018-), a dialogue between historic photographs and contemporary photography around Italian sites, monuments and artworks affected by natural disasters.

Conclusion

Catastrophes disrupt relationships between society, space, and memory. Places, monuments, and works of art acquire new meanings in the socio-spatial reconfigurations following the traumatic destruction of urban and natural environments. Beyond physical reconstruction, interventions must consider these crucial issues.

Drawing on an awareness of history and contemporary artistic practices, art history can actively confront this challenge, transforming post-catastrophe scenarios into sites of cultural agency. On the one hand, this concept alludes to the relationship between sites and creative knowledge production and, on the other, to the potential research and artistic interventions have to improve our understanding of spaces and landscapes (affected by disasters). Art history can foster theoretical reflections on past, present, and future post-disaster sites, but is also called to play an active role in their treatment between conservation, reconstruction, or creative transformation.

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OVERCOMING THE TRAUMA OF EARTHQUAKES THROUGH COLLECTIVE RITUAL. THE CASE OF CONSTANTINOPLE (5TH-6TH CENTURIES CE)

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ComPaRe: Overcoming Trauma through Collective Ritual - Adrien Palladino - <https://youtu.be/vMMs-mrvkQE>

A General Explanation of the Issues

Over 26 occurrences of major earthquakes striking large settlements in Late Antiquity are recorded just for the 5th–6th centuries. When dealing with the aftermath of such events, they were often read in an eschatological light and understood as punishments and warnings for the affected cities, bringing social tensions to the foreground. In this period, disasters notably gave rise to debates between pagans who explained catastrophes via astrology, and the Christian clergy, who explained them by citing the Bible and other sources. Through this lens, disasters were easily instrumentalized for political and religious purposes, but also became an integral part of a liturgical history which essentially re-enacted events from both historical and eschatological time.

Strategies of coping with trauma can be analyzed through the case study of Constantinople (modern-day Istanbul), located on the North Anatolian Fault (Fig. 1), where starting in the 5th century, the orthodox church commemorated a series of major earthquakes that struck the city. The aftermath of the earthquakes had to be dealt with both practically but also spiritually (and psychologically), which happened through commemoration and collective rituals. Indeed, already around 400 CE, in the words of the Church father John Chrysostom, an earthquake became a possibility to critically rethink the social structures of the city: through the destruction, the disaster allowed for a spiritual rebuilding and a levelling of social inequalities. The city had to not only be rebuilt, but also ‘re-established through the collective performance of liturgies, vigils, songs. These rituals were ways to cope with the disaster and to integrate them into the liturgical practices, then important for the collective identity of the city and ideal events for displaying the power of the clergy and the imperial administration.

Furthermore, the processions held during these commemorations reconstructed, through ritualized movement, an alternative topography within the damaged cityscape. The traumatic event was reframed within a rhetorical discourse on the physical and spiritual fortification of the city. In a homily pronounced after the earthquake of 557, the Presbyter of Constantinople, Leontius, recalled the “didactic” nature of the quake, which had “shaken” and woken up the population of the city. The liturgical commemorations were to serve precisely this idea of repentance: they were full-blown liturgical events, with readings of the Old and New Testament, psalms, hymns, as well as outdoor liturgical processions to selected sites. The main procession, held on a Sunday, began at Hagia Sophia, the Great Church, and moved towards the Campus Tribunalis, a vast field at the edge of the sea, to reenact the evacuation route that people took during the earthquakes (Fig. 2). The commemorative procession was long, around eleven kilometers, and led by the clergy, emperor, imperial dignitaries, and laypersons. It would likely have taken all day and lead the population to some of the sites which had been heavily damaged by the earthquake. The chosen texts, from hymns to psalms and passages from the Gospels, were focused on collective repentance. The people of Constantinople were associated with the people of Israel, and the quakes were framed as a manifestation of divine wrath against their lack of faithfulness. For example, the participants in the procession were compared to the exiled Israelites, crossing the Red Sea and the desert. Other episodes included Jesus calming the storm, and episodes thematizing the power of endurance, prayer, and repentance in the face of cataclysmic events. As a result, the event of the procession was a public ritual in which recent history was placed alongside other major events of the history of Christian salvation.

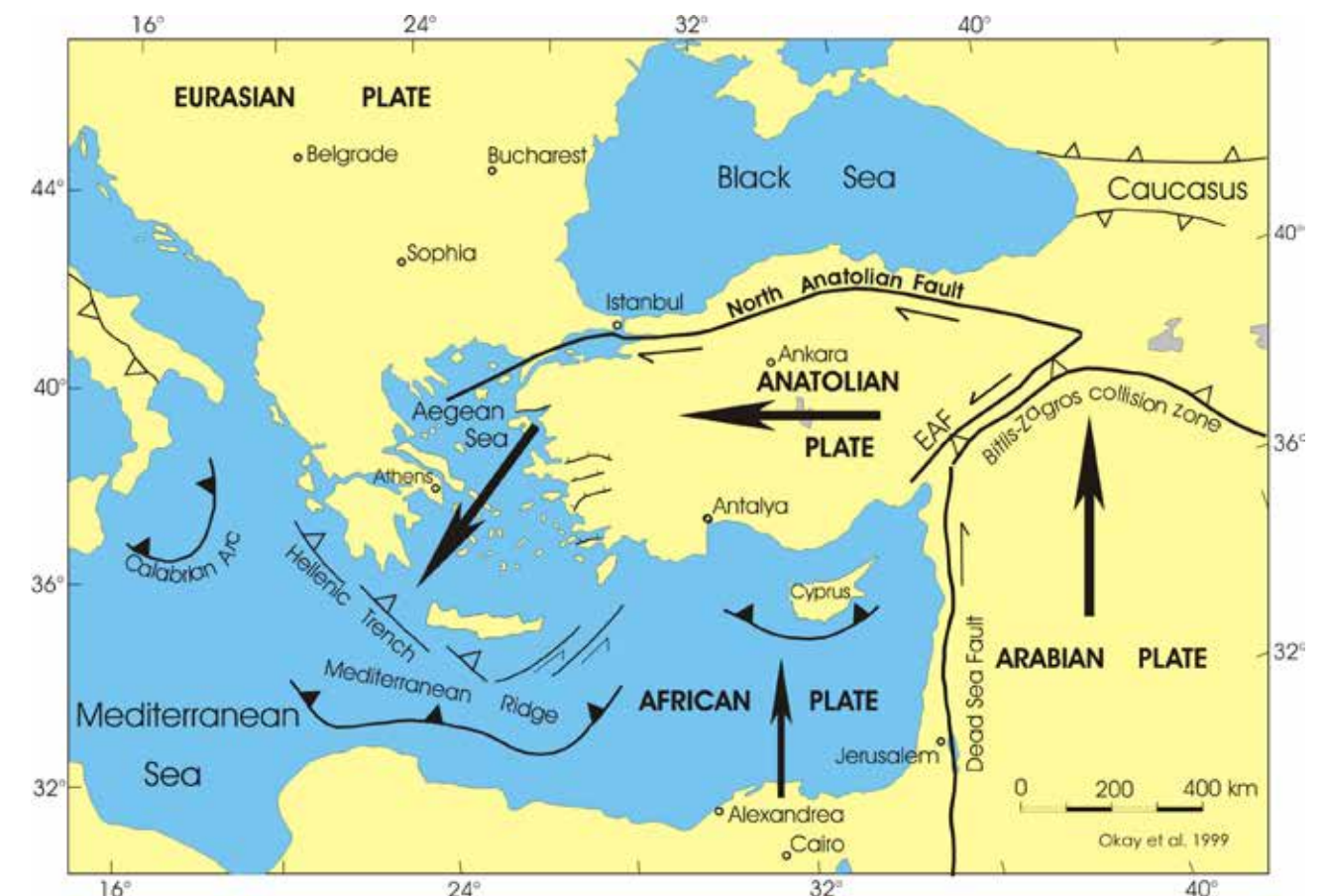


Fig. 1 Map of tectonic plaques in the eastern Mediterranean.



Fig. 2 Constantinople. Processional route from Hagia Sophia to the Campus Tribunalis (© Mark Roosen)

Key Question(s)

This text shows us a series of pre-modern attitudes to crisis management and coping with disaster trauma, extending the purely practical aspects to include spiritual, and thus psychological mechanisms. The role of religion in this process of coping with trauma cannot be underestimated, although their rhetorical use by the policymakers of the clergy and the imperial authority must also be acknowledged. The way in which the traumatic event was then remembered was the result of a “struggle in which different groups compete[d] to publicize, through cultural channels, the meaning they wish[ed] to assign to the event” (Roosien 2018, p. 20).

The procession itself, reenacting the route that the inhabitants took while fleeing the city during the earthquake, seems to correspond to the basic psychological need of reenactment as part of mastering past traumatic events. It is of course hard to reconstruct the individual experience of a participant in the procession in the fifth or sixth centuries, but it seems that the liturgical, collective reenactment corresponded to a need to remember, assimilate, integrate, and heal from the traumatic experience. Therefore, the collective performance becomes a way to deal with the trauma during its immediate aftermath, to survey what has to be reconstructed collectively, to re-sacralize the damaged cityscape, and to commemorate the dead and wounded. Subsequently, the memory of the earthquake becomes a way to acknowledge the existing dangers but also to establish, in the 5th and 6th centuries, a purely Christian cityscape in which the earthquake was both a historical and eschatological event.

Methodology adopted by lecturers

This approach wishes to highlight to the role of rituals in the rebuilding of collective civic identity after disaster. Drawing on the study of liturgy and ritual, as well as psychology and trauma theory, it seeks to understand how rituals and processions were part of the process of reforming a new topography for the city and eventually healing immediate trauma. At the same time, a critical approach to the texts also shows that commemoration was an ideal way for policymakers to enforce new norms and to capitalize on the situation.

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FROM DESTRUCTION TO CONSTRUCTION. NATURAL CATASTROPHES AND ART-MAKING IN SIXTEENTH-CENTURY BOLOGNA

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At the dawn of the sixteenth century, the city of Bologna was struck by an exceptional series of natural hazards and political upheavals. This unique intersection of environmental and human violence left behind a wake of destruction, which forced Bolognese citizens to confront fundamental questions about their urban and social structures. Through the case of Bologna, this section addresses material, artistic, and political implications that are more broadly relevant to post-disaster scenarios in Italy, both in the past and in the present.

Did Destruction Provide New Building Opportunities?

As in the aftermath of Prague's fires, which will be discussed here below, in Bologna destruction equally engendered opportunity. For the wealthiest social strata, including the urban elite, the devastation of earthquakes and battles could be used to give new, and often innovative, forms to their damaged palaces, chapels, and artworks. Destruction became part of a productive process: for instance, in Bologna it stimulated the circulation and assimilation of new architectural types, such as the increasing use of cupolas for ecclesiastical buildings (Fig. 1).

If this was true for a privileged group, for rest of the population, these disasters largely meant the worsening of their living conditions. The absence of institutional assistance, the widespread famine, the scarcity, and growing costs of building materials made reconstruction slow and expensive. Catastrophes ultimately exacerbated the pre-existing inequalities in Bolognese society.

Did the Reconstruction Process Involve Any Material Challenge or Downside?

The quasi-simultaneous occurrence of human and natural disasters in Bologna caused a significant scarcity of building material and its ensuing rising cost. A coeval chronicle recalls that after the 1505 earthquake "all this land [Bologna] is so shored up that one cannot have wood for propping up nor iron for making iron anchor plates to tie walls as everybody needs them, and anyone who wants iron to do other works cannot have it" (Tuata, ante 1521, p. 463). Scarcity triggered an intense quest for material: following the earthquakes and battles of 1511, houses were demolished, and ruins were looted to extract wood and iron, while a large portion of vegetation was cut down in the suburban areas of Bologna at a substantial environmental cost –destruction led to more destruction.

To face material shortage, measures were actively implemented. These included, amongst others, the reuse of debris from destroyed buildings, a practice already documented in ancient times (the Pompei 62 AC earthquake is a case in point). Interestingly, however, in the event of man-made "political" destruction, such material reemployment could also assume symbolic value. For instance, stones and bronze from the destroyed palace (1507) of the deposed Bolognese rulers were emblematically reused in the artistic commission marking the Pope's victory. Following another change in government (1511-12), such fragments were again repurposed, feeding a cycle of material and political re-appropriation.

How Was the Urban Space Configured and Perceived Post-catastrophe?

As in modern times, the Bolognese catastrophes were a traumatic reminder of the transience of man-made environments. On the one hand, this prompted the urge to secure it by enforcing prevention and mitigation strategies: towers were lowered, terraces (altane) were dismantled or reinforced, and iron wall ties and chains were added to increase buildings' structural strength (Boschi/Guidoboni 2003, p. 83).

On the other hand, disasters seemed to have simultaneously awakened among contemporaries a new awareness of the city space. Bolognese written sources show an increasingly conscious use of notions of 'loss' and 'irreplaceability' when recording the destruction of the surrounding environment. Concomitantly, in the aftermath of the seism, new visual considerations of the urban space arose: these included for instance Francesco Francia's so-called "Virgin of the Earthquake" (Fig. 2), a collective ex voto from the citizens, but also the first-ever documented view of Bologna. Disasters activated a material and conceptual reassessment of the city that could lead to the production of powerful objects of devotion and iconic images

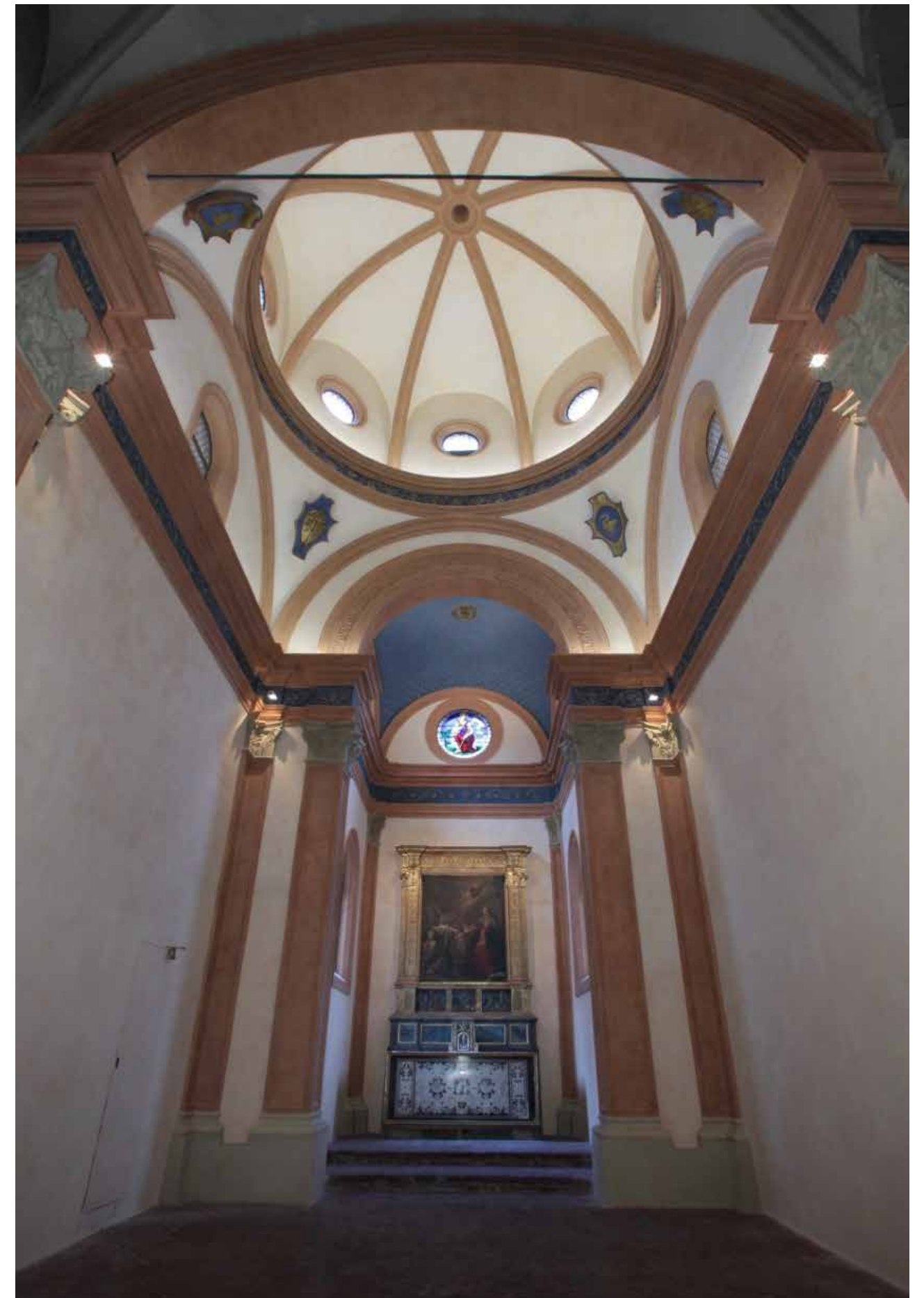


Fig. 1 Felicini Chapel (frontal view), 1517-1519. Bologna. Basilica of Santa Maria Maggiore. Cupola added in the restoration following damages to the chapel in 1506 and 1511.



Fig. 2 Francesco Raibolini (known as Francia), *Virgin and Child with View of Bologna* ("Madonna del Terremoto"), about 1505, fresco. Bologna, Palazzo Comunale, Sala d'Ercole.

Conclusion

The case of Bologna touches upon questions in part analogous to those discussed elsewhere in this chapter, disaster as "opportunity", material implications, prevention and mitigation strategies. But it also offers further insight into the interconnected relationship between the two contrasting moments of a building's life in the early-modern period: destruction and reconstruction. It shows how these phases can be mutually dependent and cyclically informed, devastation stimulating production but also further destruction, and to what extent social preconditions and local traditions can affect rebuilding mechanisms.

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DESTRUCTION AS A OPPORTUNITY: GREAT FIRES IN PARDUBICE (1507, 1538), PRAGUE (1541) AND OLOMOUC (1709) AS TURNING POINTS OF RENAISSANCE AND BAROQUE URBAN DEVELOPMENT AND VISUAL CULTURE

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ComPaRe: Destruction as a Chance - Ondřej Jakubec <https://youtu.be/yvPASYSji8k>

Can we always understand disaster as a negative phenomenon? The word catastrophe itself (from the Greek καταστροφή/katastrophé) is not only related to the meaning of destruction, but also refers to the significance of an upheaval; characteristically, its Latin equivalent is conversio, and the German translation Umwendung may also be close. A disaster is therefore always associated with a reversal, and despite all its negative manifestations and consequences, it is fundamentally associated with an opportunity for transformation.

Especially for the cities of the pre-modern era, fires were the most frequent and most destructive disasters, affecting them with relentless regularity not only materially, but also in terms of social structure. However, for urban communities, fires were not only a threat, but also a frequent stimulus for the development of urban space, urban planning and social structure. In this sense, catastrophic fires also had a positive “restart” effect, analogous to how, for example, forest fires become a starting point for ecosystem restructuring. Similarly, social and urban structures represent systems in which a catastrophic fire (as a critical moment) can initiate similar mechanisms of renovation, restructuring and modernization.

Case Studies: Pardubice, Prague, Olomouc

Can these general assumptions about fires as opportunities for restoration be substantiated with specific historical examples? Three examples can illustrate this concretely.

1) Two fires in the town of Pardubice in Eastern Bohemia (1507, 1538) act as typical examples of the transformation of a small, provincial town with a village character into a new form (Fig. 1). They contributed both to the expansion of its area and to a new, unifying development according to a unified plan, in which the virtuous late Gothic elements were transformed into fashionable early Renaissance decorative forms on the constructions of the town houses. The ordinance of the city owner focused on the visual unity and safety of the new development. The renewal also brought a social transformation of the town, as the older population was moved to the suburbs and a new, socially higher class found its way into the newly built town.

2) The fire of Prague on June 2, 1541, had a devastating impact on the most important, formerly historically independent parts of the city (Fig. 2). The fire destroyed approximately 66% of the buildings of Lesser Town and almost the entire area of Hradčany, the district with the royal residence and the cathedral. The subsequent transformation brought a fundamental change in these urban areas: palaces and houses were built on larger, unified plots, also with greater height, previously empty areas were built over, and new Renaissance elements (shields, attics) were used. The reconstruction was carried out with new groups of craftsmen and artists from the Ticino area, with whom the spread of the new Renaissance style is associated, and who made a significant contribution to the restoration. The renewal transformed the city socially as well - it brought the nobility and other numerous inhabitants (who were connected both to aristocratic and court circles) to the new palaces to a greater extent.

3) On June 21, 1709, a fire broke out in Olomouc, capital of Moravia, which destroyed a significant portion of its centre and destroyed more than half (350) of the city's houses (Fig. 3). The subsequent restoration not only created space for a specific highly Baroque transformation of the city but was also interesting from the point of view of immediate reaction. It was accompanied by an extraordinary solidarity of individuals and institutions. The reaction of the municipality was also typical – it took the opportunity of the renovation to modernize the city and ordered owners to restore their houses in the same way, ideally better form, and directly condemned the provisional and otherwise "deforming" renovation. The experience from the fire was reflected in the publication of a new fire order, which introduced new preventive and safety principles.

All these examples have shown how it is possible to reflect historically on the phenomenon of fires in pre-modern cities. Historical research provides a considerable number of reports and descriptions, both contemporary and later, in which fires resonate for a long time in historical memory. Historical sources from the urban environment also demonstrate the social transformation that cities underwent as part of their reconstruction after fires. A new population often settled here, taking advantage of this opportunity, which often represented a qualitative development of urban society from a social, economic, cultural and professional point of view. Building-analytical and art-historical methods also provide a range of information about the fundamental construction and urban transformation of cities, not only in the sense of application of new stylistic elements, but in general also in more ambitious, qualitative and quantitative, construction.

Conclusion

What do the three examples of historical cities in Central Europe that were hit by devastating fires tell us? In addition to historical information about the fatal impact on the urban organism, it is also a positive effect that the disaster brought. Despite its considerably devastating scope, in all cases it became a stimulus for the fundamental renewal of urban spaces. From the perspective of art history, it is remarkable how these moments became the trigger mechanism for the development of new artistic forms, which fundamentally changed the current cityscapes. This did not only apply to buildings, but also to other artistic decorations, as well as newly used safety and construction technologies (especially with an emphasis on masonry and durable materials). In addition, the fires caused considerable changes in the social structure of the cities, when it can be observed that a new community was born on the ruins of the old city, in which newcomers played an important role. An interesting source is the various official regulations, which not only dealt with fire protection, but also established binding rules for building renovation, the goal of which was a better-quality appearance of the reconstructed cities. In summary, fires in pre-modern cities should not be understood only as devastating traumas (resonating in collective memory), but also as catalysts for a cityscape's transformation, which was of a complex, urban-artistic and social nature. At the same time, this disaster-management also took on fundamental socio-mental importance by strengthening the resilience of the community.

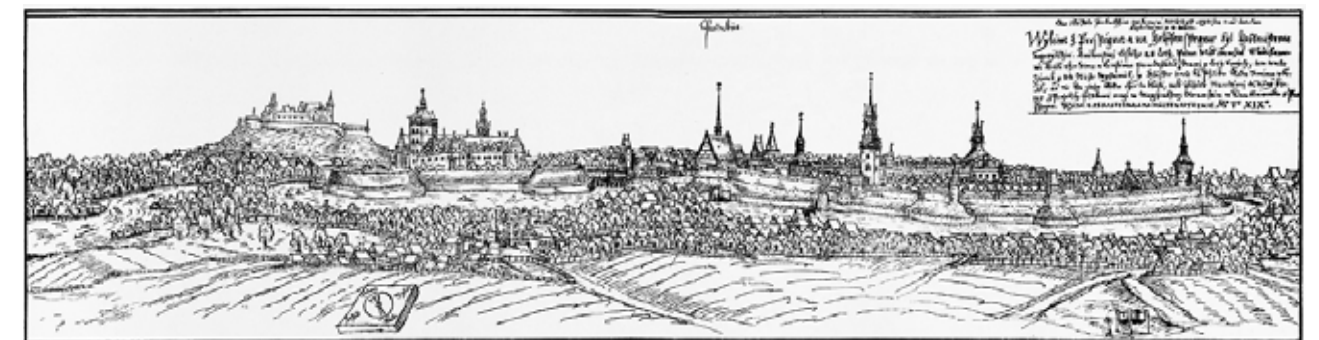


Fig. 1 Johann Willenberger, *View on Pardubice*, 1602, drawing (in case of low quality it is possible to use 10b: Georg Matthäus Vischer, *View on Pardubice*, 1688)



Fig. 2 Great Fire of Prague in 1541, woodcut, British Library



Fig. 3 Mark Abraham Ruprecht and Johann Christoph Hafner, *View on Olomouc*, before 1754, engraving.

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HOW IS MEMORY ERASED? THE CASE OF ANI IN THE 20TH CENTURY*

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ComPaRe: Ani and its Hinterland - Ivan Foletti - <https://youtu.be/nylZ7v1SWc4>

The city of Ani-now located in eastern Turkey-and its environs are now sprinkled with desolate ruins, submerged in a breathtaking arid landscape (Fig. 1). Isolated from the world and far from major tourist routes, it is a kind of forgotten gem of European heritage. Its history is one of wonderful vibrancy and gradual decline, but also of systematic destruction by nature and man. Paradoxically, the damage suffered is not only related to destructive activity, but also to very questionable restoration operations.

What Was the City of Ani Like in the Early Medieval Era?

The city of Ani, founded by the Kamsarakan dynasty in the fifth century A.D., became the capital of the Bagratuni kingdom during the ninth century. Located on a Caucasus plateau, the city was built in close proximity to a very steep canyon. In its heyday, during the regnal years of Gagik I (989-1020), the city had dozens of churches, palaces, and an impenetrable wall. The last years of the 10th century also saw the construction of the sumptuous cathedral, built by the celebrated architect Trdat, who additionally restored the collapsed dome of Justinian's Hagia Sophia in Constantinople. The building, still standing, is entirely constructed out of volcanic stone, and is a notable example of the skill of Armenian architects and builders (Fig. 2). The pseudo-basilica was crowned with a majestic dome, and adorned with monumental paintings, originally being the tallest monument in Ani (38 meters high). The building, prepared for pre-Chalcedonite Armenian church worship, cites late antique monuments, but does so with exceptional technical prowess.

In the medieval period, an intercultural community lived in these wings - also consisting of palaces, streets with merchants' stores, public lighting, and channelization - dominated by the Armenian language, but with Georgian, Arabic and the Western languages present daily in a decidedly cosmopolitan environment at the crossroads of Asia and Europe. The city fell to the Seljukid Turks in 1064, and then in 1201 became part of the Georgian Kingdom. Despite these political changes, the city remained an essential landmark of the region until the ruinous earthquake of 1319, an event from which the city never recovered, leading to its gradual abandonment in the following centuries.

What Does the City of Ani Look like Today?

Therefore, today the city looks like a majestic ruin - a dozen or so churches still stand, although sometimes in a very precarious condition. However, the city wall is preserved in excellent condition, and the remains of the royal palace are also recognizable. Furthermore, archaeological excavations have revealed the existence of at least fifty sacred buildings. In 2015 Ani was added to the UNESCO list of monuments. Since then, regular restoration and maintenance work has begun to take place in the ancient city. To the unsuspecting visitor, it is coming back to life. Their captivation with the city seems to be demonstrated by the increasing number of tourists visiting annually: approximately over 60,000 in 2019, with nearly 100,000 in 2022, the first year after the coronavirus pandemic.

Destruction or Restoration in Ani?

At first glance, then, the city seems to be flourishing again under the supervision of international organisations. The reality, however, is much more complex: the restorations, visible here and there around the city, seems to be very invasive. This is especially evident when it comes to the city walls and one of the palaces, as one can see with the naked eye that the buildings have been reconstructed in a way that recreates an ideal original state. This was a common approach during the nineteenth century - developed by figures such as Eugène Emmanuel Viollet-le-Duc - but difficult to adopt today, since the ideal state that tends to be reconstructed never corresponds to reality of the past. In the case of the walls, then, the restorers used original archaeological material (remnants of earlier walls that collapsed), making it much more difficult to understand what the original elements were. Much more serious, however, was that as the walls were being



Fig. 1 The medieval Armenian city of Ani, viewed from Armenia, 2009 (photo: Haigoes, © Wikimedia Free Commons).



Fig. 2 The Cathedral of Ani, 2017 (photo: Katarína Kravčíková, © Center for Early Medieval Studies).

restored, Armenian inscriptions and images of crosses drawn on their surfaces had disappeared. Unfortunately, in all likelihood, this was no accident: the relationship between Turkey, the country in which Ani is located today, and the region's Armenian past has been very complicated for more than a century. In fact, after 1915, the Ottoman state organized the systematic liquidation of all Armenian inhabitants of the region. These actions, costing the lives of about 1.5 million civilians, are considered by most states as "Armenian genocide." Yet, this assessment is still denied by the Turkish state, which speaks instead of a civil war resulting in 300,000 casualties on each side. Erasing the Armenian dimension of Ani's monuments might then correspond to a conscious desire for denial. This hypothesis becomes even more plausible when one enters the surrounding countryside. There one finds medieval monuments of exceptional quality that were clearly subject to systematic destruction by means of heavy military (Fig. 3-4). Moreover, even today, these remains are regularly visited by tomb latri and vandals. In all likelihood, restorations and destructions thus have a similar goal, that of the erasing of the memory of Armenian presence in this region. Thus, in this case, restoration becomes a political tool.



Fig. 3 The Khtzkonk Monastery in the early 20th century (© Wikimedia Free Commons)



Fig. 4 The Khtzkonk Monastery in the early 21st century photo: Katarína Kravčíková, © Center for Early Medieval Studies).

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TALES OF RECONSTRUCTION

Section

1

Tales from the contemporary

THE 2016 CENTRAL ITALY EARTHQUAKE. WAITING FOR RECONSTRUCTION

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Abstract

The 2016 Central Italy earthquake affected a portion of the sub-Apennine territory that spans 4 regions, 10 provinces, 138 municipalities, and encompasses a total territory of approximately 8,000 square kilometres. A population of 600,000 people was involved, with a high number of lost lives, injured, and people displaced. According to the history of natural disasters in Italy, reconstruction is emerging as a delayed process that only in recent months seems to have started; a top-down process that has greatly burdened communities. In a scenario of great landscape value, communities already subject to depopulation and economic depletion still experience, eight years later, a condition of crisis dictated by the delay in reconstruction and the lack of policies to keep these communities alive in the long period from the disaster until the reconstruction is completed. Small temporary settlements, built in the aftermath of the earthquake, are the new urban system in which only part of the population has decided to settle, rather than abandon their territories, as others have done. Observing the impacts of a highly destructive earthquake on communities in the so-called "inland areas" it is necessary to grasp how the impoverishment of a community's intangible values (social relations, quality of living, etc.) can be even more serious than the loss of the buildings.

What the residents want is the bond between people that they used to have, and an intimate cosmos that gives them the feeling of a home in which they have been living in for a long time.

Toyo Ito (2012)

Italy as a seismic area

Throughout history, the Italian territory has been subjected to a number of significant seismic events and other forms of natural disasters, which have resulted in varying responses from affected communities. Indeed, the approaches to reconstruction that have emerged over time have yielded disparate outcomes and remain without a unified, effective model —or models— based on validated methodologies that delineate the roles of the involved parties, the appropriate implementation strategies for identified case studies, and the requisite time frames for definition and application in post-emergency processes (Orazi 2023). The approaches adopted have been in fact strongly conditioned by the political sensitivities present during the acute phase of the emergency and in the subsequent phase of organizing post-emergency reconstruction.

The Italian approach to emergency management and reconstruction is characterised by two distinguishing factors: firstly, the response to the initial emergency, both in terms of health care and sheltering people in provisional accommodations; secondly, the duration between the occurrence of a calamitous event and the reconstruction of buildings and infrastructure, which has resulted in many cases in the social disruption of communities. The following is a list of major seismic events that have occurred in Italy over the past 50 years, along with the estimated timescale for reconstruction following each one of them: Belice, 1968/2028 (forecast); Friuli, 1976/1986; Irpinia, 1980/2023; Marche/Umbria, 1997/2025 (forecast); Puglia/Molise, 2002/2023; L'Aquila, 2009/2023. In the majority of cases, the displaced population has been obliged to reside in temporary accommodations or hotel facilities, which has resulted in the progressive and subsequent abandonment of their original homes. The prolonged tenure of affected communities in provisional accommodations has frequently resulted in a novel crisis that is exceedingly challenging to navigate, with profound ramifications for psychological and social well-being. Indeed, individuals may experience significant frustration when compelled to reside in uncertain circumstances and an unsuitable setting for an extended period (Betts et al., 2015). This aspect has been particularly relevant in rural and inland areas, often already marked - as in Italy are - by accessibility problems, social and economic fragility (De Certau 1984).

Material and immaterial damage in inland disaster areas

The earthquake that affected Central Italy in 2016 was characterized by two highly destructive moments (Aug. 24, 2016, Oct. 26 and 30, 2016) and a subsequent dense and intense seismic activity. The affected community has about a total of 600,000 residents dislocated in a portion of territory that includes 4 regions (Abruzzo, Latium, Marche and Umbria) 10 provinces, 138 municipalities (Fig.1), for a total of approximately 8,000 square kilometres (CSRS, 2016). The seismic sequence of more than 92 thousand quakes, 9 of which were of magnitude 5 or greater, that has struck central Italy since August 4, in addition to costing 303 lives and injuring 388 people, has created a total of about 40 thousand displaced persons (DPC, 2018). Only 6 of the 138 affected municipalities were home to a resident population of more than 20,000: in fact, most are settlements with a very small number of inhabitants, 40 percent less than 1,000.

More than single buildings, this earthquake severely hit a quantitatively and qualitatively considerable part of the Italian “system of villages”, which can be defined as a peculiar and consolidated landscape, environmental and production system. This context revealed a high level of criticality concerning not only the issue of reconstruction but also the possibility of rebuilding communities that were experiencing, even before the earthquake, a condition of social and economic crisis: low population density; urban conformation made up of small towns in a wide territory, orographically rugged and little connected to the major urban centers; an often obsolete building patrimony, realized with traditional building systems prior to 1971 (year of the anti-seismic regulations); an asphyxiated economy mainly of agri-food and more recently tourism. The depopulation was and is a constant phenomenon proper of sub-Apennine regions, inland areas of great cultural and landscape value but far from major urban centres and many primary services, featured by the inadequacy of housing standards to the aspirations of the inhabitants (especially the younger) and the lack of job opportunities, with the exception of the areas with the greatest tourist vocation (De Rossi 2019).

Even before the earthquake, this area was already characterized by social and demographic fragilities, that the seismic event exacerbated. Between 2016 and 2022, there was a decrease in the population of the crater of 6.3 percent, which corresponds to about 36,600 fewer people, worse than the negative curve underway in the rest of the country. Some studies have shown that the effect resulting from the impact of the earthquake significantly accentuated the demographic decline already taking place in those portions of the territory (Dottori, 2023). The crater areas, already characterized by negative demographic trends (Boeri et al, 2017) and densities significantly lower than the regional ones (Ordinance No. 36 of September 8th, 2017), turned out to be subject to depopulation dynamics triggered by multiple factors related to the earthquake, lack of sense of security, poverty of services, reduced job opportunities, thus reinforcing the pre-existing characteristics of the elderly social fabric in the affected territory (Dottori, 2024). In addition, a large part of the population



Fig. 1 The central Italy 2016 earthquake crater.

has been relocated to hotel facilities placed in coastal cities where some still reside or have decided to abandon the region and migrate elsewhere.

Eight years after these disaster events the scenario turns out to be composite. Reconstruction of private houses and restoration of some monuments and public buildings has slowly begun. However, there are still 30,000 individuals who have not yet been able to return to their homes (CSRS, 2024). How have they lived for the past these eight years? What policies have been practiced by the national government to manage this phase that has been, yes, temporary, but too long not to mark an indelible trauma in the community?

Precisely these data certify a likely irreversible loss of the intangible heritage of these places due, evidently, to insufficient policies to manage the transition between seismic events and reconstruction.

When reconstruction is completed, what community will be resettled? Certainly, a wounded and very different community from the original one. And, so far, what kind of reconstruction will have to be carried out and for what users?

The italian way to manage affected communities in the extended period of time between disaster event and reconstruction

The organizational strategy that allows people to live in affected places waiting for reconstruction to be completed, as is well known, is strongly focused on the operation of temporary settlements on site. Recent examples of reconstruction in Italy include the cases of L'Aquila (2009) and the Umbria (1997) earthquake, which represent two different approaches to managing the intermediate phase between the disastrous event and the reconstruction.

The reconstruction of L'Aquila involved the implementation of unconventional strategic choices with respect to the prevailing culture of reconstruction in Italy, typically based on the practice of rebuilding as it was and where it was (Nastasi 2015). In particular, the process led within a few months after the 2009 earthquake to the creation of “New Towns” for a large part of housing displaced people. “Progetto C.A.S.E.” is the name of this program: it distributed settlements made by two and three-story prefabricated timber buildings, fixed on large seismically isolated reinforced concrete slabs for a total of 184 slabs distributed in 19 areas around L'Aquila [1]. Compared to the building types and the actual urban pattern of L'Aquila before the earthquake, these building types seem far distant from the local living and housing culture. The intention of minimizing the inconvenience resulting from the extended period of waiting for reconstruction, the need to provide citizens with comfort and seismic safety permanent housing, and also the idea of demonstrating that a strongly top-down model can prove effective and decisive in the reconstruction process, led to the creation of a permanent “foreign body” in the city. Furthermore, this model exhibited other several shortcomings, including extensive land consumption, a lack of integration of services, distance from the original centers and public transportation, as well as the premature obsolescence of some materials and components and the alienating effect of the adopted settlement layouts, which were similar to suburban dormitories. These factors negatively impacted the community's well-being and quality of life (Santi 2016; Grappasoni, et al. 2017; Coppola, 2018).

At its opposite, the one adopted following the 1997 Umbria reconstruction process, was characterized by the use of housing containers located near the affected centers, while having the advantages of rapid installation and de-installation was found to be particularly deficient in terms of thermal comfort. In this case, therefore, the strategy was to provide the populations with temporary accommodation as soon as possible (Di Pietro, 2021), which however proved inadequate for the “transfer” of the same population from the original settlement to this new and unsatisfactory city.

In light of the insights gleaned from these and earlier models, the 2016 organizing facility could have devised a strategy anchored in the tenet of safeguarding the sense of community by concurrently addressing the reconstitution of the urbs and civitas and the potential for an authentic, albeit not necessarily identical, reconstruction of the social relations that unfolded in those spaces (Ordinance No. 107/2020 [2]).

[1] On this point, cf. <https://www.peri.it/progetti/edilizia-residenziale/progetto-case-abruzzo.html>.

[2] Ordinances are regulations issued by the Special Commissioner for Reconstruction. They are issued periodically and contain, among other information, provisions on the use of funds allocated for reconstruction. See also note no. 5

This awareness seemed to be the basis of the policies implemented after 2016, as well as other aspects such as: the understanding that, in the time of waiting, the human relationships that are the basis of any concept of community should be restored as soon as possible (Ruggiero 2018); the possibility of actively involving the affected population in the reconstruction processes should acquire considerable relevance (Bulsei, 2017).

In this theoretical perspective, after the 2016 event, to carry out this kind of stitching together activity in the best way, local government assumed a pivotal role, as a hinge element between supra-local planning and the local population, precisely with a view to fostering participation or at least forms of involvement and sharing.

Ordinance no. 36/2017 identified from the very first article the general principles regarding participation, stating that the reconstruction activity must be carried out precisely «through the analysis of the potential of the territories and individual existing production chains through ways of listening and consultation» of the populations of the municipalities affected by the earthquake, as well as their associations or popular participation bodies established for the protection of widespread interests. In the premises, the community was described as an active entity in the reconstruction process, capable of self-organising not only to defend the right to regain their private homes, but also to protect the public space of the community and its relations, in order to promote physical, economic and social recovery (Polci, 2023).

Instead, those considerations have found little space and the reconstruction process has been configured as a top-down action, suffered rather than managed by the population. This has concerned not only the reconstruction process, but also the management of the long-awaited phase of the reconstruction itself that we can consider one of the critical issues underlying the loss of value of the intangible heritage of this communities.

The S.A.E. model and the waiting time

The idea to manage the phase in-between disaster and reconstruction was based on on-site [3] intervention which was supposed to facilitate in re-establishing a certain “normality” made up of daily habits and routines. To achieve this goal, it was therefore necessary to configure temporary settlements, characterized by the use of single-family and prefabricated housing modules, easy to install and, at least in the premises, quick to un-install; aggregations capable of setting up, albeit in the contingent reduced form of temporariness, forms of community unity. The framework agreement prepared even before the earthquake, signed in May 2016, by the Prime Minister's Office and the Department of Civil Protection, established the characteristics of the modules defined as Housing Solutions for Emergency (SAEs), costs, modalities and timing of provision in case of emergency. The implementing entities for the provision of SAEs are the Abruzzo, Lazio, Marche and Umbria regions, as indicated by Ordinance No. 394 of Sept. 19 (DPC, 2018). SAEs are configured as anti-seismic and prefabricated housing units of 40, 60 and 80sqm according to the number of household members, designed as modules for variable settlement layouts based on the geo-morphological configurations of the site.

A special technical specification is drawn up that also defines that the SAEs must have an expected service life of 10 years, features of removability, flexibility and adaptability in the case of on-site conversion for other uses. The framework agreement also establishes costs that include the supply, transport and assembly of the temporary modules but not also all related works (Passananti, 2019). A total of about 3,800 SAEs organized in 220 temporary settlements to accommodate 7100 citizens were installed in the earthquake crater territory of central Italy (Della Valle, 2022) [4]. The spatial-functional organization of the temporary SAE settlements follows rational land-use logics also with a view to favouring the orderly passage of road vehicles, parking lots and distribution of sub-services, within portions of the territory located in the vicinity of the affected towns and identified by the municipalities. In fact, the new villages are characterised by their arrangement in relation to parallel axes without hierarchy, according to repetitive and recurrent arrangements (Fig. 2,3), with reduced attention to the specificities of the territory and with a poor provision of public spaces (Passananti, 2019).

[3] However, it is interesting to point out that it has not always been possible to build settlements on site: the most evident cases are those of Accumoli and Pioraco

[4] SAEs are not the only tool institutions use to respond to the demand for housing assistance, but together with CAS (Contributo di Autonomia Sistemazione) and MAPRE (Moduli Abitativi Provvisori Rurali di Emergenza) they are the most widely used forms.



Fig. 2,3 Temporary settlements in Muccia and Pieve Torina, central Italy (2017).

The issue of housing assistance, as it is effectively configured in the arrangements assumed by the realised settlements, does not find an accurate answer in the ability to experience space outside the confines of the home. The possibility of being inhabitants of a community, in that waiting phase that acts as a trait d'union between before and after, part of the premise repeatedly enunciated upstream from the reconstruction process, clashes with the limited endowment of citizen-friendly open spaces and the lack of public equipment capable of fostering encounters and relational dynamics (Mariani, 2023).

In addition, the construction of the temporary settlements aimed at the installation of SAEs required intervention through a systemic series of prodromal land transformation works (Fig. 4,5,6): consolidation structures, construction of service roads and connections to the existing road system, parking spaces for cars, sewage collection conduits, sewage treatment plants, water and electricity networks, domestic fuel gas networks, telephone networks, public lighting, works that affected land consumption (ISPRA, 2018). Entire portions of the territory that host the new urban agglomerations are born under emergency conditions often in derogation of existing regulations and constraining regimes, inconsistently or in the absence of urban plans (Tonti et al. 2024) constituting de facto real temporary cities (Di Venosa, et al. 2017). The literature, in critically interpreting the model used, has expressed questions about the degree of environmental, social and economic sustainability of the operation, also because of the effects derived from past experiences: post-emergency interventions conceived as temporary, have in fact turned into permanent ones with time (Bologna, 2020): the shacks in Messina in 1908, the terraces in Belice in 1968, the prefabricated villages in Irpinia in 1980, portions of the territory in San Giuliano di Puglia (2002), the infrastructure in Nocera Umbra (1997), to name a few.

The reports of the Extraordinary Commissioner[5] that follow one another over the past few years photograph how progressively the issue of reconstruction has actually come into its own and how with the passing of the years critical housing situations are gradually decreasing (CSRS, 2023; CSRS, 2024). The issue is framed because of the guarantee of ensuring that all eligible people are able to return to their own homes, or with a view to proceeding as quickly as possible with the reconstruction of affected settlements and structures. The narrative focus used does not address the issue of the temporariness of artifacts and settlements -except in numerical terms referring to the number of temporary structures used and in terms of comparison with previous years. The landscape of temporary settlement, although in practice it contributes heavily to the transformation of the territory, is in fact considered emergency, and therefore secondary, of lesser importance than the ongoing reconstructive procedures of the physical centers.

[5] The commissarial structure is a body specifically dedicated to post-earthquake reconstruction. Among its various responsibilities, it coordinates reconstruction activities with the aim of overcoming the state of emergency and facilitating reconstruction efforts, it exercises control over any other planned activities, maintains and manages the special accounting.



Fig. 4 La Serra, SAEs temporary settlement, Pieve Torina, 2024. Photo by Timothy D. Brownlee.



Fig. 6 SAEs temporary settlement in Muccia, 2024. Photo by Timothy D. Brownlee.



Fig. 5 La Serra, SAEs temporary settlement, Pieve Torina, 2024. Photo by Timothy D. Brownlee.

Conclusions: Enabling temporary open systems

The organizational model, which was developed prior to the 2016 earthquake events and was based on the use of SAE units, lacked the capacity to anticipate the significant variability that was required in the context of the emergency. The model turned out to be more complex and burdensome than expected in terms of its ability to be effectively applied to an essentially mountainous area that required adequate infrastructure (Mariani, 2022). The realisation of temporary urban structures and, consequently, the whole process of reconstruction in central Italy, which promoted and generated forms of entrepreneurial economy in the field of construction, took the shape of an essentially top-down phenomenon that produced late responses, inadequate in housing supply and in providing perspectives of the future for the citizens involved. In the everydayness of the waiting time, living in temporary modules is evidently configured as an emergency practice and the inhabitants are temporary tenants within housing solutions owned by the Department of Civil Protection (Della Valle, 2022). As the operational cycle comes to an end, years later and because of possible future emergencies, it is necessary to conduct an analysis of what will happen to these settlements tomorrow and what is being handed over to the next generations also in terms of emergency cultural baggage.

Will action be taken by completely dismantling the built structures, or is it assumed that they will be reused on site? Will a relocation/transformation scenario of the temporary modules be envisioned by imagining an extension of their life cycle, or will this not be possible since, in the waiting time, they will have exhausted their operational capacities? What will happen to the infrastructure spaces, i.e., the largely artificialized and sealed portions of land, once the S.A.E.s are disassembled and relocated?

With respect to the quantity of interventions carried out, the economic cost required for their implementation [6] and the type of materials and construction techniques used that are typical of ordinary

[6] The total cost of SAEs was subject to significant variation based on the geo-morphological characteristics of the site in question. This is influenced by the presence of pre-existing urbanization and the proximity of the temporary settlement to infrastructure. It is estimated that in some cases, the total cost required has exceeded 6,000 euros psqm, with a minimum cost of 2,500 euros psqm

construction, i.e., permanent, one wonders about the possibility of identifying possible circular approaches, capable of acting contextually on the dimension of risk and fragility of the territory (Tonti et al., 2024). In light of the fact that if we exclude a few virtuous examples [7], eight years later it can be seen that in terms of citizen involvement and participation in choices regarding temporary settlements little has been done (Orazi, 2023), it may be interesting, at this point of the process, to initiate a real involvement of local authorities and communities that poses as a question for discussion the hypotheses of future reprogramming of what reconstruction delivers us today.

Clearly, the topic of post-emergency management is an ongoing challenge that needs constant adjustment and analysis, but the case study of central Italy can offer numerous frameworks for inspiration and host forms of experimentation. The space of the central Apennines, which has experienced the effects of several earthquakes over the years and now photographs a changing landscape that is the result of stratifications of successive temporalities (Tonti et al., 2024), can still be a candidate ground for social innovation scenarios. Some of the reconstruction models used in Japan suggest that it is possible to identify solutions capable of effectively responding to the sudden housing emergency through the direct activation of communities, while at the same time seizing the opportunity to design innovative solutions in terms of environmental sustainability (Ito, 2012). For example, the urgent questions raised by the ongoing environmental crisis, which call for a rapid change in the approach to construction, could be answered by the use of lightweight and dismountable building systems, which can be considered in terms of the entire life cycle of the building and the settlement. Moreover, it seems topical to ask what strategies could be really effective in order to avoid that populations remain passive actors in reconstruction processes or, even worse, that the late activation of such processes could lead to changes in housing demand once transformations have already begun. With a view to seeking approaches capable of *listening* to citizens, truly oriented towards the needs of earthquake-affected communities (Félix, et al., 2015), and having learnt that *waiting times* can indeed extend over several years, sometimes decades, it is necessary to place at the centre of planning strategic choices that consider possibilities for adaptation over time, as needs change (Perriccioli, 2005), in an ever-present dimension of impermanence. For example, it would be useful to recognise the complexity and variability of the issue of impermanence and to identify a design dignity that allows tools for continuous transformation within open systems (Vannelli, Rossi-Schwarzenbeck 2022) and that allows for adaptive and incremental maintenance.

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REFINERY APOLLO AND WINTER HARBOR IN BRATISLAVA/MULTIPLE DISASTERS AND YET A SUCCESS STORY

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Abstract

The case study (of historical or contemporary examples) in this chapter explaining replicable teaching method/ instrument that is trying to return the works to life can be called "virtual renewal". There are similar projects in the world often appear as "digital reconstruction". Virtual method recovery is also a learning method that was in collaboration with students successfully tested even during the pandemics times. Students are able to study architectural works within real site and students can also verify the current state of the object in-situ via the "Urban Walk - Interactive planning method" in conjunction with the "Before after method". As a case study for the Multidimensional model was tested the zone around the former refinery Apollo and Winter harbour in Bratislava, which survived several disasters. The first one was its bombing during World War 2nd and the second one was the demolition of its industrial heritage ten years ago of which only a few fragments remain. Despite this, the recognized potential of the zone was not unused and it is currently one of the most lucrative parts of Bratislava.

Creating of a multidimensional model requires several methods of digital mapping or visualization including the use of virtual and augmented reality. Multidisciplinary cooperation is an integral part of any assignment of this type, which has been confirmed. The principle of interdisciplinary cooperation is not only synergistic element in a complex scheme of organized design process, but also a key educational element. The case study through Multidimensional model has reinterpreted the history of the cultural industrial heritage which it was not possible to recover in physical reality and have brought it to a contemporary audience. Through this practical interactive tool, the general public can learn about lost heritage and find the possible alternatives and ways for reconstruction of Urban Structures.

History of Refinery Apollo and Winter harbor in Bratislava

The Chalupkova zone in the Old Town of Bratislava was once the area with the highest concentration of industrial enterprises within the city. Along with the Winter Harbor, it was historically one of the most significant industrial centers in the Kingdom of Hungary. Today, this zone is undergoing a radical transformation, evolving into a new downtown area with residential, administrative, and commercial functions. However, several valuable historical buildings from the city's prominent industrial era have been preserved.

This area partially reflects the broader societal approach to industrial heritage preservation. The remnants of former industrial enterprises now exist in entirely different urban contexts compared to their original state. Often overlooked and misunderstood, these buildings are perceived as burdens within the framework of rapid urban development. They stand as silent observers of dramatic changes and demolitions in their surroundings, yet they also serve as beacons of industrial history, highlighting the technological, economic, social, political, and cultural aspects of their era. Residents of the newly developed district, as well as local Bratislava citizens and tourists, have limited opportunities to learn about the historical significance of this area.

Industrial heritage represents one of the most important records of urban and regional development. Monumental industrial structures reflect the remarkable technical and economic boom of their era, showcasing the progress of science and technology, particularly over the past two centuries. Even after their original functions have ceased, their architecture continues to significantly contribute to the atmosphere of every city. Due to urban expansion, non-functional industrial buildings have gradually found themselves in zones of active development. Currently, the unilateral approach of certain development projects has led to the indiscriminate demolition of abandoned industrial sites without thorough consideration of their potential reuse or assessment of their possible broader societal significance.

The fifth edition of Industrial Days aimed to map and highlight the values of industrial heritage in the areas around Mlynské Nivy, the Chalupkova zone, and the Winter Harbor in Bratislava.

Participatory planning process of urban structure conversion

The comprehensive participatory planning process in this case was composed of a mosaic of various events and activities, emphasizing the importance of this zone for the development of Bratislava. The events were preceded by research, the results of which were showcased in an exhibition titled "Around Apolka," open to the general public at the Design Factory, one of the preserved original industrial buildings in the area. This research also served as the basis for creating a map of the former industrial zone, guiding visitors through the preserved remnants of production activities during a planned walking tour called the Industrial Walk. Subsequently, in collaboration with the Faculty of Architecture and Design at STU, a series of expert lectures and presentations was conducted, culminating in a public professional discussion, the Industrial Talk, which included representatives from the local government.

Comprehensive research of this zone was first conducted under the leadership of the Municipal Institute for the Protection of Monuments (formerly the Municipal Administration for Monument Preservation and Nature Conservation in Bratislava) by Ing. arch. Anna Schwarczová in the 1970s and early 1980s. Unfortunately, this research has not been preserved in a comprehensive form to this day. A more complete outline of the industrial history is offered in the works of another employee of the Municipal Institute for the Protection of Monuments, PhDr. Viera Obuchová, CSc. [1] However, it can generally be stated that this topic remains insufficiently explored and even less published, not only in the context of the city's history but also in broader contexts.

The city's historically most significant industrial area, which once housed one of the key refineries during World War II, is currently undergoing a transformation into a new mixed-use center. Exactly 75 years ago, this location was targeted by Allied bombers. This event was commemorated by the story of Europe's youngest spy, Trixi, featured in the documentary series Prvá, [2] which was screened during the opening event of Industrial Days, Industrial Cinema. The bombing marked the beginning of a fascinating story of transformation for the entire Apolka area, as well as the story of the Design Factory building itself, under which many people found refuge in an underground shelter.

With the assistance of PhDr. Zvarová, it was rediscovered that the basement of the building houses the only fully preserved air-raid shelter from the former Apollo refinery. Built to accommodate 380 people, it is likely unparalleled within the city. The building serves as an example of the architectural design of the Apollo refinery and is a typical representation of an industrial hall from the 1940s. In light of recent extensive demolitions of entire production complexes, the significance and value of the former locksmith and carpentry workshop have significantly increased.

Research has confirmed that the Design Factory building on Bottova Street in Bratislava, along with the Jurkovič Heating Plant, is currently one of the last two remaining structures of the original Apollo Refinery. The building carries direct architectural and historical values derived from its construction, but it also holds indirect values linking it to the refinery site and to Bratislava's first direct encounter with war—the bombing of the refinery on June 16, 1944. [3] This functional industrial building exemplifies the architecture of

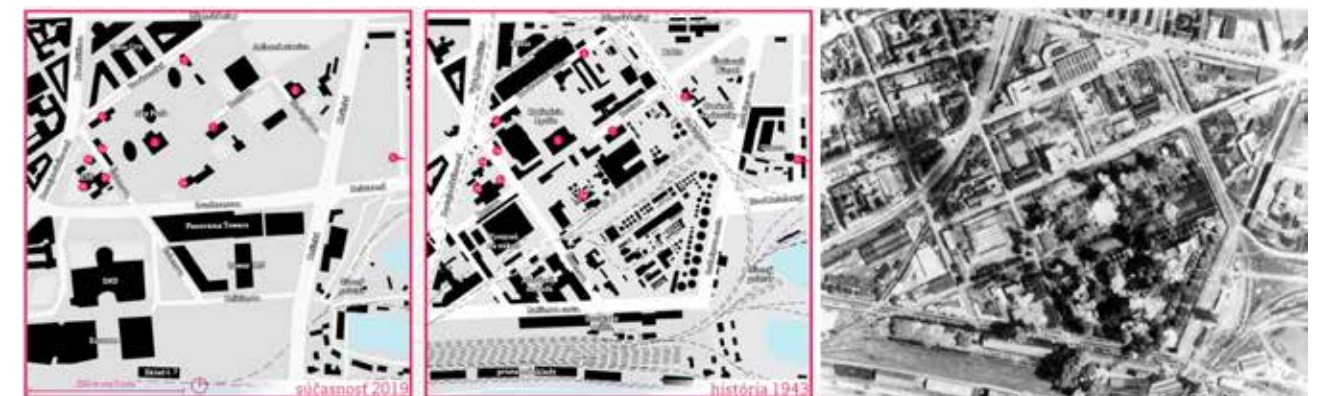


Fig. 1. Map of the Industrial Walk - History and Bombing of the Chalupkova Zone from 1945. Map authors: Eva Belláková, Graphics: Ľubomír Dait, Bombing photograph source: Book "Bombs Over Bratislava."

contemporary modernity, consisting of two longitudinal sections: a single-nave hall with two above-ground levels of administrative and support spaces. This atypical spatial-operational concept was so adaptable that the building has not undergone any significant structural alterations to date. It retains many original elements and details, preserving its authenticity and uniqueness. Most notably, its location at the center of the former industrial zone anchors the historical urban setting and testifies to the cultural-historical layer and scale of the entire former industrial district.

The entire area is currently undergoing a similarly radical transformation. In the recent past, bulldozers were reshaping it, and now it is being transformed by developers. The civic association Design Factory has been a part of this zone since 2005 and is now documenting its own history while fighting to preserve the building and the shelter that have survived until today. Efforts to declare the building a municipal heritage site began early in the research, based on newly discovered facts. It was during this process that the idea to focus the Industrial Days event on the industrial zone around the Design Factory building was conceived.

The ongoing massive construction activities and the current bustling work environment in the Bratislava Mlynské Nivy area, specifically the Chalupkova zone, bring with them justifiable expectations from the residents of Bratislava. For this reason, an event called "Industrial Walk – A Walk Around Apolka" took place on Monday, September 16, 2019. The walk included seven stops, where approximately 50 participants engaged in discussions about the remnants of the industrial zone, its direction, future, and its value to society.



Fig. 2. First and second floors of the current Design Factory building as shown in the historical drawing by Pittel & Brausewetter from 1942. Source: Bratislava City Archives, Chief Architect's Office Collection, file 380.

Industrial walk

The Industrial Walk (IW) is based on the international format of the Urban Walk and was guided by architect Tomáš Hanáček, who has been actively engaged with this concept for a long time. The method of interactive planning through the Urban Walk operates on the principle of guided tours, during which the public actively participates in discussions about the future of their city. The main goal is to highlight the current needs of people in urban environments, with a focus on pedestrian movement and spaces for people to gather.

This was the fifth planning walk, and the fourth to take place in Bratislava (previously held at Kamenné Square, Karloveské rameno, and under the SNP Bridge). Along the route, information panels were set up at

various points, detailing the history of the location, current issues, and possible changes illustrated through sketches. Participants of the planning walk engaged directly in the discussion, contributing their feedback through written notes at each micro-space and industrial building along the way.

The route of the walk started from Design Factory, passing by the Jurkovič Heating Plant, and then proceeded to Orbán's Butchery. Participants of the Industrial Walk continued along Továrenská Street to the Klingerka (Tatrabanka) building, and viewed the premises of the ZSE complex. On Landererova Street, the walk featured a virtual connection to the Apollo Club, ending back at Design Factory. Dozens of participants received a Slovak-English map of the route and stickers on which they could write down their ideas and suggestions, attaching them directly to prepared boards. So far, three public walks have been conducted on the dates of 16.09., 26.09., and 04.10.2019, and 65 suggestions have been collected. All of these were gathered and evaluated.



Fig. 3. The Apollo Refinery and Kablo Plant from the north side during the bombing on June 16, 1944. - In the upper part of the photograph, amidst the smoke of burning oil or petroleum, the building of today's Design Factory is visible, with its northwest corner hit during the bombing. Source: Slovnaft, a. s. Archive.



Fig. 4. Comparison of the original scale of Design Factory with the current construction activity in the Chalupkova zone. Source: Archive of Slovnaft, a. s. and drone photograph from April 2019, source: Design Factory.



Fig. 5. Participants of the Industrial Walk at the Orbán building and the former Oriental store of the Bezák family on Továrenská Street, photo by Ľubomír Dait.

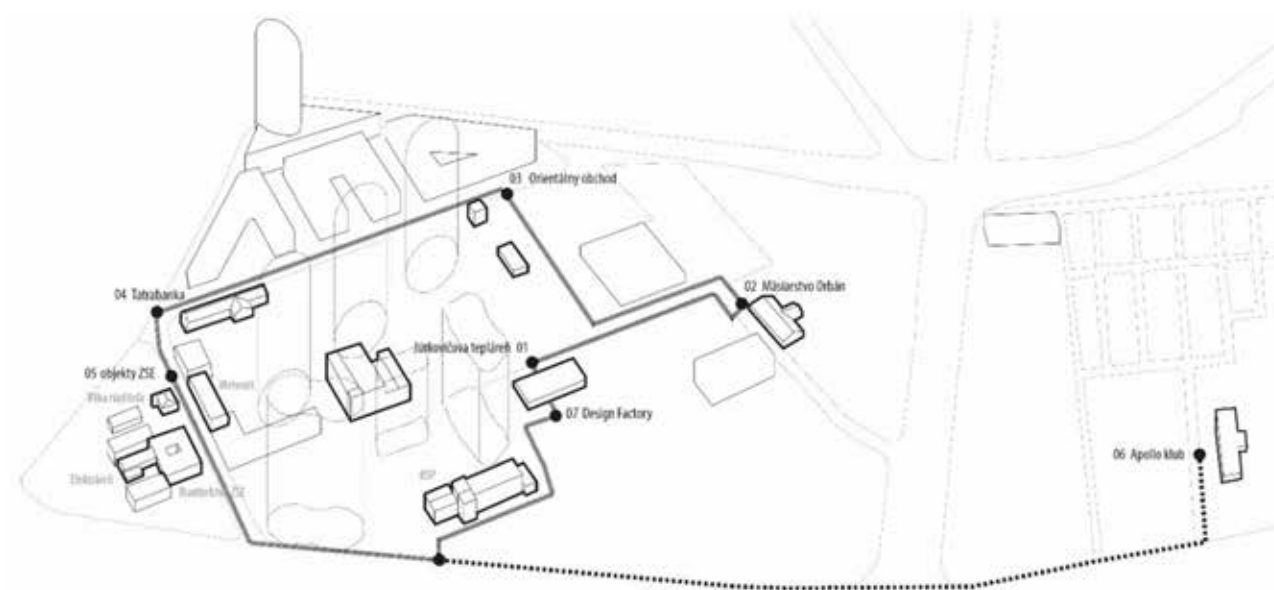


Fig. 6. Route of the pedestrian Industrial Walk with marked bicycle route to Apollo Club, source: T. Hanáček.



Fig. 7. Participants of the Industrial Walk in front of the Klingerka (Tatrabanka) building, photo: Ľ. Dait.

The summary evaluation reveals:

1. Consensus Points:

- The industrial past of this key development area in Bratislava should not be forgotten and should be more prominently showcased, primarily through the physical preservation of multiple structures.
- In addition to preserving the NKP Jurkovič Heating Plant and Klingerka, other industrial buildings should also be preserved/adapted.
- There is a desire to maintain the Design Factory building in its current form due to its atmosphere, scale, and social function.
- The former Orbán Butchery should be transformed into a local market/biofarming hub, incorporating beehives and community engagement.
- The University Library warehouse could be repurposed as a summer reading room, a bookstore with a greenhouse, or a kindergarten.
- Key ZSE properties, such as the villa, Meteorit Theater, Power Plant, and ZSE Headquarters, should be integrated into the new development.
- The idea of making the Apollo Club and the entire Slovnaft zone accessible by bicycles is welcomed.
- Buildings should be assessed based on the values of their structure, stories, and history, rather than just the current state of their facades.
- There is a need to apply modern forms of presenting industrial heritage using QR codes, interactive information panels, or virtual reality as part of a learning trail.

2. Unresolved Issues:

- How can we contribute to preserving as many authentic structures as possible in this area?
- What should be the function of each building at the street level?
- What kind of urban environment does Továrenská Street offer between the bus station and the city center?
- Is it possible to make key listed buildings at least partially accessible to the public?
- What are the benefits of combining high-rise buildings with former industrial structures for Bratislava?

3. Future Considerations:

- The lack of basic life infrastructure — kindergartens, children's centers, libraries, reading rooms, yoga centers, and cinemas.
- The issue of the urban ground floor: What can industrial buildings offer beyond their specific atmosphere in the future?
- The quality of public spaces, including streets, parks, squares, rooftop landscapes, and corners of the former industrial zone.
- A broader, more complex, and multi-layered perspective on the city.



Fig. 8. Method of gathering public feedback using stickers on prepared information boards, photo by Ľ. Dait.

The Industrial Days program continued with lectures by experts—historians and architects from the Faculty of Architecture at the Slovak University of Technology, the Department of Architecture at the Institute of History of the Slovak Academy of Sciences, the Municipal Institute for Monument Preservation in Bratislava, the Association of Slovak Architects, and other organizations. This so-called Industrial Talk provided a professional perspective on the former industrial zone of the Apollo refinery, as well as a dynamic discussion on its transformation into a new, modern urban district.

In the presence of the Chief Architect of Bratislava, Ms. Ingrid Konrád, and the event's ambassador, Associate Professor Eva Kráľová, CSc., from the Institute of History and Theory of Architecture and Monument Restoration at the Faculty of Architecture, STU, along with Prof. Ing. arch. Henrieta Moravčíková, PhD., from the Slovak Academy of Sciences, the discussion included references to international conventions and charters for the protection of industrial heritage from TICCIH, along with statements such as:

"The loss of a cultural heritage object (whether through natural decay or demolition) always results in an irreplaceable loss of information. Even if the original structure is replaced by a new one that is 'nicer and better,' it will convey a different message: a reflection of the conditions, mindset, and abilities of the time and people who constructed it anew. It will also serve as a testament to the mindset and actions of those who effectively disregarded and erased (wiped from history) the achievements of previous generations."

(E. Kráľová)

The growing body of research, international and multidisciplinary collaboration, as well as community initiatives over recent decades, have significantly contributed to the valorization of industrial heritage and enhanced cooperation among custodians, stakeholders, and professionals. [4] Preserving and revitalizing unused industrial sites is often a possibility that owners and investors find difficult to envision. From the outset, they tend to develop alternatives focused on new construction, which seemingly appears to be less time-consuming and financially demanding. However, this approach fails to consider the risks of invasive environmental change, lack of character, and potential rejection by the community. Industrial buildings, having been an integral part of the area (or city) for decades, are embedded in the mental (spatial, navigational, emotional) maps of residents, which, with proper marketing, can serve as a significant (and quantifiable) added value.



Fig. 9. Industrial Talk at Design Factory with the presence of experts and the Chief Architect of Bratislava. Photo: Ľubomír Dait



Fig. 10. : PhDr. Zuzana Zvarová from the City Institute for Monument Protection of Bratislava delivered the opening lecture on the history of Apollo, accompanied by a photograph of the model of the original Chalupkova zone in 1943. Photo: Ľubomír Dait



Fig. 11. Industrial Exhibition held directly in the targeted area within the premises of Design Factory. Photo: Ľubomír Dait

The participants of the expert colloquium and the Industrial Walk agreed that without preserving the identity and physical remnants of the last remaining structures of the Chalupkova industrial zone, this unique area would transform into a modern space, but one that is ultimately banal in terms of atmosphere and history.

The event culminated in a moderated discussion titled Industrial Stories with individuals who had memories of Apolky, led by Mgr. Ivica Horáková. Due to the significant public interest in this topic, a new format of moderated discussions with both professionals and the general public, named Industrial Breakfasts, was subsequently established at Design Factory. Through collaboration with the civic association Čierne diery, the Industrial Days project featured an original graphic of the Design Factory building created by Karol Trnovský, which he presented on October 15th. The Industrial Walk was repeated twice more in October, including sessions specifically for employees of the Bratislava City Council.

Based on the results from the next meeting of the Commission for Culture, Media, and Cultural Heritage Protection of the City Council held on October 2, 2019, and the update of the Comprehensive List of Heritage Sites in Bratislava, the Design Factory building was declared a heritage site of the capital city of Slovakia by City Council Resolution No. 315/2019 on October 24, 2019. In the Chalupkova zone, it thus joined two national cultural monuments (Tepláreň Čulenova and Klingerka), which already had a certain level of heritage protection. The Jurkovič Heating Plant and the entire area have become a unique space that brings together cultural and artistic events, workshops, markets, a café, a restaurant, and shared workspaces where everyone is welcome. The flexible office spaces will serve as a home for startups, freelancers, bloggers, vloggers, new ideas, and anyone else who wants to join.

This confirmed that multidisciplinary research, along with community initiatives, can contribute to the valorization of industrial heritage and foster enhanced collaboration between property owners, local government, stakeholders, and architects.



Fig. 12. Industrial Stories moderated by Ivica Horáková in the premises of Design Factory. Photo: Ľubomír Dait.



Fig. 13. The final design solution for the Chalupkova zone and downtown area by Zaha Hadid Architects, integrating the original industrial layer at the ground level, featuring the unique atmosphere of the Jurkovič Heating Plant. Photo: Design Factory, 2023.

Multidimensional model of the site

The Faculty of Architecture and Design of STU has created for this locality multidimensional models within the vertical studio Data[LAB], thanks to the support from the projects KEGA 051STU-4/2021 and APVV-18-0044. Physical model with digital backlighting of the central part of Bratislava city, integrating multiple contextual data layers. These layers include traffic patterns, significant historic buildings, existing building programs, planned developments, green spaces, noise maps, shadow maps, key viewpoints, solar irradiation levels, flood control measures, and the historical evolution of the Danube River's shape. Displayed through LED screen backlighting 3D printed transparent buildings, these dimensions provide valuable design inputs for current and future students' academic projects. The focus of the multidimensional model is to serve as a contextual model for upcoming academic and city projects in collaboration with the Metropolitan Institute of Bratislava.

Prototype of the model, along with its digital component, has been already utilized as an interactive contextual model in 14 academic projects. [5] It has been showcased in six midterm and four final reviews, effectively communicating the ideas of these academic projects to juries and professionals. These exhibitions

provided platforms to showcase the model to a diverse audience, raising awareness about urban development and shaping the city's image. Beyond its educational value for students, the model serves as a teaching tool for the public and younger generations, fostering a deeper understanding of urban planning principles and encouraging active participation in shaping the future of the city.

Based on all the mentioned examples, multidimensional models integrate different virtual layer display technology: backlighting, projection, augmented or virtual reality. Each technology has its advantages and disadvantages. Backlit models offer the most impressive experience, but only with flat models, while the backlight limits the material of at least part of the model to transparent. The model is thus less legible under standard lighting.[6]

However, the multidimensional model can be variable in space and time and can combine backlighting, AR projection, VR into one whole, which was also the purpose of this verification study. (Fig. 15)

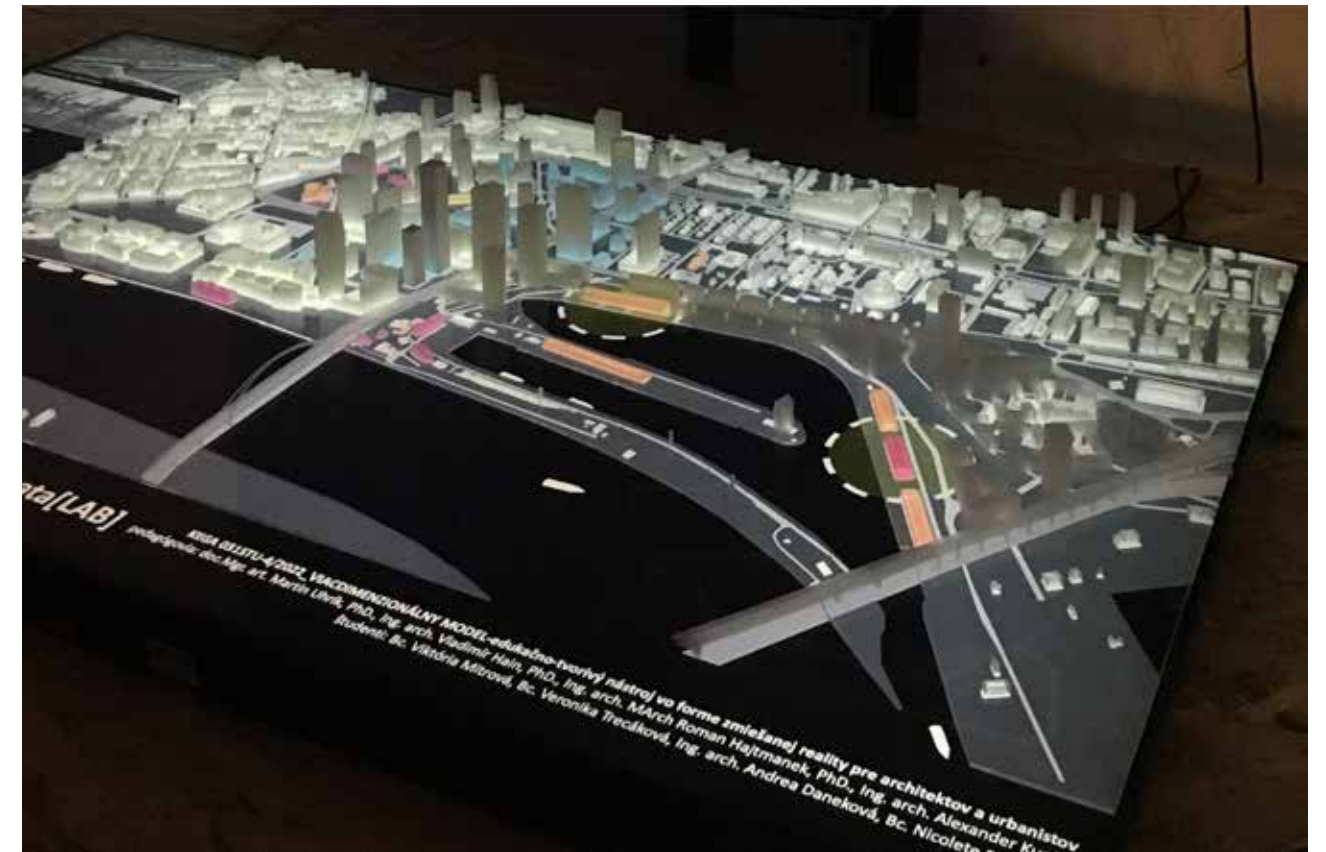


Fig. 14. Urban model of the Winter Harbor and its surroundings showing the historical development of the zone and its possible future scenarios. Source: V. Hain, R. Hajtmanek, M. Uhrík, A. Kupko, V. Mitrová, V. Trecáková, Data[LAB].



Fig. 15. Urban model of Bratislava with projected layer and 3D virtual layers displayed with 2D markers. (Source: Authors, FAD STU, Data[LAB], 2024).

Digital layers on models variably display development scenarios for construction, transportation, flood control activities, and the historical evolution of the area. From an artistic perspective, the models allow for the assessment of the city's silhouette and skyline during the construction of high-rise buildings, as well as concepts for nighttime illumination.

The models also offer the possibility of linking the physical model, which provides fundamental information about mass and space, with virtual reality (VR), which enables the visualization of the experience from a human perspective and aids in popularizing urban planning and design.

The combination of a physical model enhanced with VR is a technologically simpler option. However, VR also has its limitations and it restricts the observer to view the physical model and 3D visualizations sequentially, which can cause confusion.

To select the appropriate technology for displaying the additional layer, it is crucial to simultaneously and carefully consider the model's height, materiality, available technical equipment, and the lighting conditions in the space where the model will be exhibited.

To select the appropriate technology for displaying the additional layer, it is crucial to simultaneously and carefully consider the model's height, materiality, available technical equipment, and the lighting conditions in the space where the model will be exhibited.

Conclusion

"A building has at least two lives - the one imagined by its maker and the life it lives afterward - and they are never the same."

(Rem Koolhaas)

The quote by architect and theorist Rem Koolhaas perfectly captures the essence. Digital technologies and tools for mixed, augmented, extended, and virtual reality assist the creator in better visualizing their intent, and subsequently, enable more credible communication of that intent to investors and the general public. However, even these tools do not guarantee that the realized structure or the final outcome will be identical. They remain, fundamentally, tools to aid the architect's creative process.

As with every construction, each case of architectural presentation requires a specific, detailed study and an informed decision about the choice of representation methods. This chapter aimed to orient readers within this field and serve as a model for individual applications in education at the Faculty of Architecture and Design, Slovak University of Technology (FAD STU), as well as in future practice.

Given the continuous evolution of technology, it is necessary to further deepen the theoretical foundations in other courses and design studios. The primary challenge is not to fear experimenting and, during one's studies, to confront newly acquired knowledge with one's own creative work.

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SAFEGUARDING AND RESTORATION OF THE HERITAGE IN DANGER: THE BANSKÁ ŠTIAVNICA BAROQUE CALVARY COMPLEX

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Abstract

Damage and losses of cultural heritage can be the result of natural disasters, but also of human activities or neglect. The case of the Banská Štiavnica Calvary is an example of how forced interruption of use, neglect, and the abandoning of a complex can attract vandalism, theft and accelerate decay caused by atmospheric impacts and uncontrolled vegetation expansion. The example of such a case is the Baroque architectural and landscape monument – the religious Calvary complex. As a consequence of communist regime the original association for maintenance of the site has been lost. From 2007 there was a huge and strong community initiative for the safeguarding the unique Baroque complex with high architectural, historic and urban values. The Slovak University of Technology Faculty of architecture and Design in Bratislava was one of the initiators in setting up a scientific approach to the Calvary restoration and conservation, based on the results of scientific discussions and multidisciplinary researches.

The article explains the strategy of a combined approach: public participatory approach, authorities' engagement, management and fundraising on one hand, and development of a scientific methodology for the conservation and restoration interventions on the other hand. The case study introduces this huge project with many disciplines involved in the restoration and in the effort of assuring a sustainable future for the site. The methodology of restoration was not simple, since the site comprises many historical, urban, architectural, religious values and also landscape values. All the aspects had to be solved simultaneously and it was necessary to set the methodology on a multidisciplinary scale and provide for appropriate logistics management of the process.

The challenge of Saving the Calvary

The important Baroque landscape and architectural landmark – the Banská Štiavnica Calvary situated on the summit of the sacred hill Scharffenberg has, unfortunately, become an example of a massive decay due to lack of interest, abandonment, deterioration and vandalism. Unprofessional interventions during socialism (1979 – 1981), communist restrictions related to its religious pilgrimage use also contributed to the losses of historical architectural and urban values, which were bigger than those in consequence of World War II.

The gradual disinterest of the public caused that after the year 2000 the state of the monument could be described as alarming. At that time, local experts started initiatives to save it. However, many efforts failed due to lack of funds.

a/ Banská Štiavnica – the Historical Context

Banská Štiavnica was established and developed in a very complicated natural environment amidst the volcanic mountains of Central Slovakia, at the latest from the beginning of the 12th century. Every century left an imprint on the city. On the slopes above the valley covered with palaces, poor miners also built their tiny houses, coming there for work and settling near the mines. The profit made in the mines was reflected in the richness of the architecture, the quality of the craftwork, and the artistic ornaments of the palaces, churches, and schools.

The mountainous landscape also inspired the Baroque builders, starting from the end of the 17th century, to take advantage of the natural landscape phenomenon. In the 18th century, important architectural structures were built on distinct hilltops and became the dominant features in the city's panorama. This period was marked by the most intense development of mining – the mining of gold and silver and all of the related mining industry has always been an integral part of the long and rich history of the town. It was naturally accompanied by developments in science, technology, knowledge, education, art, and architecture. The city's 18th century boom was its high point to date, thanks to which it was possible to preserve in the mediaeval urban plan the original mediaeval buildings, although in a Baroque "dress" (facades as another cultural layer).

The protected area today is not only the representative city centre and the Baroque Calvary as a dominant landmark, but also the larger area of technical and industrial complexes related to mining. The mining shafts, galleries, towers, and ingenious water supply network of the "tajchs" (reservoirs) together form an important part of the town's cultural heritage. These values were the reason for the 1993 inscription of the city and its surroundings on the UNESCO List of World Heritage Sites, entitled "Banská Štiavnica and the Technical Monuments in its Vicinity", comprising an area of 20 632 hectares.



Fig. 1 Banská Štiavnica – panoramic view of the historic town formed in the hilly context. Photo by Lubomír Lužina.

b/ The Baroque Calvary (1744 – 1751)

Since the middle of the 18th century, the city belonged to the biggest and most influential free royal towns of the Hungarian kingdom and its mining industry experienced its golden period. Favourable economic conditions provided for the unprecedented cultural development and brought about changes in the town's outer appearance including the construction of a unique Calvary Complex.

This sacred complex is an extremely impressive Baroque area and prominent landmark. The perfectly elaborated composition of architecture, sculptures, paintings and craftwork in unity with the natural environment literally drags visitors into the story that brings to life the scenes of the last journey of Jesus – the Way of the Cross. (Čičo, Kalinová & Paulusová, 2002).

The architectural complex consists of 17 stations, three churches (the Lower Church, the Holy Stairs, and the Upper Church) and three smaller chapels (Ecce homo, the jail, and

Jesus' Tomb) and finally, the stone statue Seven Sorrows of Virgin Mary. The complex takes advantage in an especially sensitive way of the properties of the natural environment (Vošková, 2024).

As one of the most important representatives of Baroque sacred architecture in its typological class in Europe and it has become part of the atlas network of the European Calvaries and Holy Mountains, which were surveyed in 2001 by the Italian Istituto Geografico DeAgnostini (Barbero & Bilská-Wodecka, 2001).



Fig. 2 Banská Štiavnica Calvary, situated on the hill Scharffenberg above the town. Photo by Tomáš Mlynárik.



Fig. 3 Coloured copper engraving of the Baroque architectural concept of the Calvary Complex in Banská Štiavnica from 1751 (Johann Michael Pfrimb – Thomas Messmer, 1812, Vienna). Slovak Mining Museum in Banská Štiavnica.

The Calvary at the beginning of the 21st century

The Calvary had unfortunately found itself under serious threat at the beginning of the 21st century. The loss of cultural-historical values during the period between 1989 – 2004 is incalculable. As a paradox at that same time the Calvary complex has become a part of the area of the UNESCO World Heritage Site.

The consequences of long-term neglect and the past unprofessional repairs led to the following problems:

- Abandoned state of the complex, no maintenance, the landscape architectural landmark covered by overgrown neglected greenery;

- Vandalism – destroyed roofs, stolen and destroyed furniture (altars, sculptures);
- Inappropriate technologies used during the communist regime (concrete and cement technologies in 1978 – 1981);
- Inappropriate modifications of the original urban concept – three chapels had been relocated from the original place and the pilgrim road had been shortened;
- High humidity of the walls of Churches and chapels – no provision for water drainage from the slope of the Calvary Hill;
- Lack of interests of the public

The challenges and measures to be taken were becoming clear: permanent maintenance, site security and protection, further research and setting up a restoration methodology; updating of the zoning master plan for the Calvary area, studies and proposals for the moisture elimination, involvement of the local authorities and public, revitalisation of greenery based on professional research of original and new plants.

The year 2007 meant a breakthrough in the modern fate of the Calvary. Thanks to the initiative of local activists, the Calvary complex was enrolled to the World Monuments Watch 2008 List of 100 Most Endangered Sites (World Monuments Fund, 2008). This fact had made an impact in the community, motivated activists (Baden-Powell Foundation and Association for Banská Štiavnica'91) and the key institutes (the Roman-Catholic Church, City of Banská Štiavnica and Slovak Mining Museum) to take further steps in order to save and rehabilitate the Calvary. In 2008 a civic association, the Calvary Fund, was established uniting relevant owners, professional institutions (Faculty of Architecture and Design of SUT and the Slovak Mining Museum) and activists from the civic associations. From the first moment the Fund had been in systematic charge of the professional conservation of the monument as a complex, and cared for its appropriate protection and revitalisation. The present Calvary Fund continues the historical tradition of protecting, maintaining, and embellishing the Calvary complex – an activity originally performed by the initiator of its construction, Jesuit Father František Perger (1700 – 1772) (Čičo, Kalinová & Paulusová, 2002). The former Calvary Fund had been established in 1751 and functioned until 1951, when its activities were stopped by the communist regime after exactly 200 years (Vošková, 2024). Since 2009, the Calvary Fund has gradually coordinated the restoration of three churches, seventeen chapels, three specific objects in the composition (God's Tomb, Pilate's Palace – the Ecce homo chapel and the Statue of the Sorrowful Virgin Mary on the pedestal), and has been taking care of permanent maintenance of the area – mowing, repairing retaining walls, sidewalks, access roads.

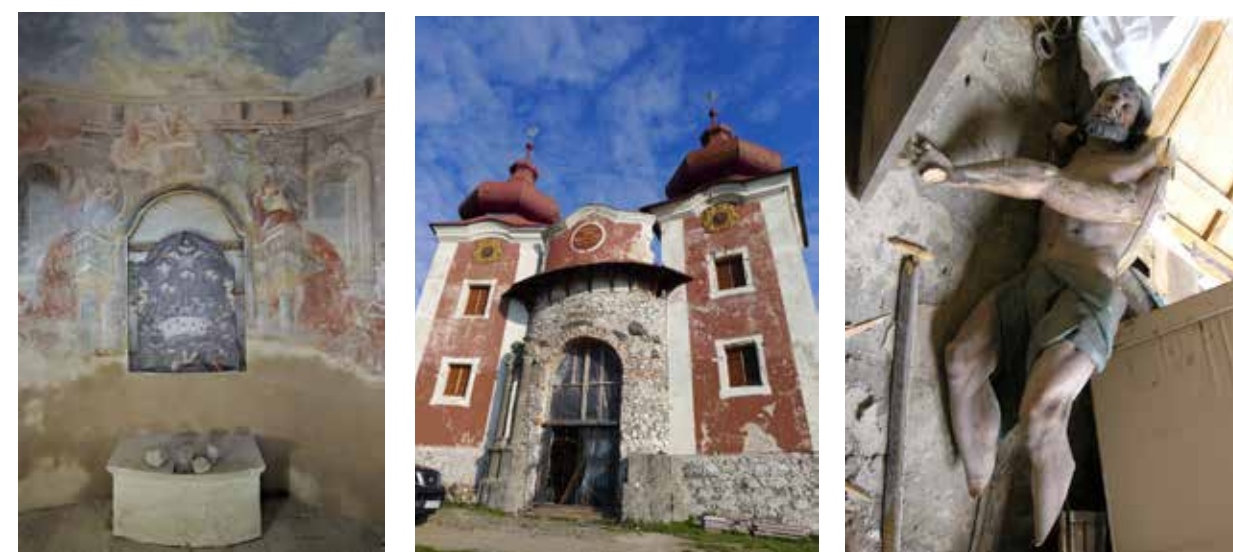


Fig. 4,5,6 Condition of the Baroque architecture and art before 2007: Interior of the Lower Church, Façade of the Upper Church, Wooden Baroque sculpture from the Upper Church. Photo by Katarína Terao Vošková..

Professional steps and methodology to save and restore the Calvary. The specific role of the Faculty of Architecture and Design

The Slovak University of technology Faculty of Architecture and Design has played a key role— after initiating the nomination to the List of 100 the Most Endangered Monuments in the World it set up the rescue and recovery methodology and continues to take part in the leadership of the scientific multidisciplinary research and coordination of the restoration. In 2007 it organized an international scientific colloquium and workshop *Banská Štiavnica Calvary – Prospect of its Revitalization*. Accompanying events – such as the opening of the long-term exhibition *Calvary in Asylum, the Calvary in Photography* – also involved the local lay public and community. Thus, a general platform was created for dialogue and for signing a Memorandum of Cooperation for the restoration of the Calvary. A team of experts outlined urgent, medium-term and long-term activities that would contribute to the preservation and revitalization of the monument based on the results of the "Colloquium Outcomes" (Vošková, 2008). The specific methodology was adopted in result of a number of multidisciplinary researches and international scientific colloquia in 2007, 2014.

The restoration methodology was set up in accordance with Cesare Brandi's theoretical principles (Brandi, 1963), the ICOMOS Charters of Athens and Venice, as well as the Document on Authenticity. Its formulation was preceded by a series of steps. After completing measure drawings of the churches, chapels and sculptural elements, multidisciplinary researches had been launched: archeological (discovering an anti-Turkish probably wooden watch tower on the top of Calvary hill on a stone basis), architectural-historical of the development of construction stages (traces of the Baroque architectural concept were found), conservator-restorer research (the fresco decoration of facades and interiors of churches and chapels had been revealed), survey of the wooden furniture of churches and chapels and stone sculptural decoration; art historical archival research of historical documentation (original copper engravings and depictions of the complex before and during construction);



Fig. 7,8 Signing of the Memorandum on cooperation in saving the Calvary and Opening of the Exhibition Calvary in Asylum – involvement of local authorities and owners. Archive of authors.

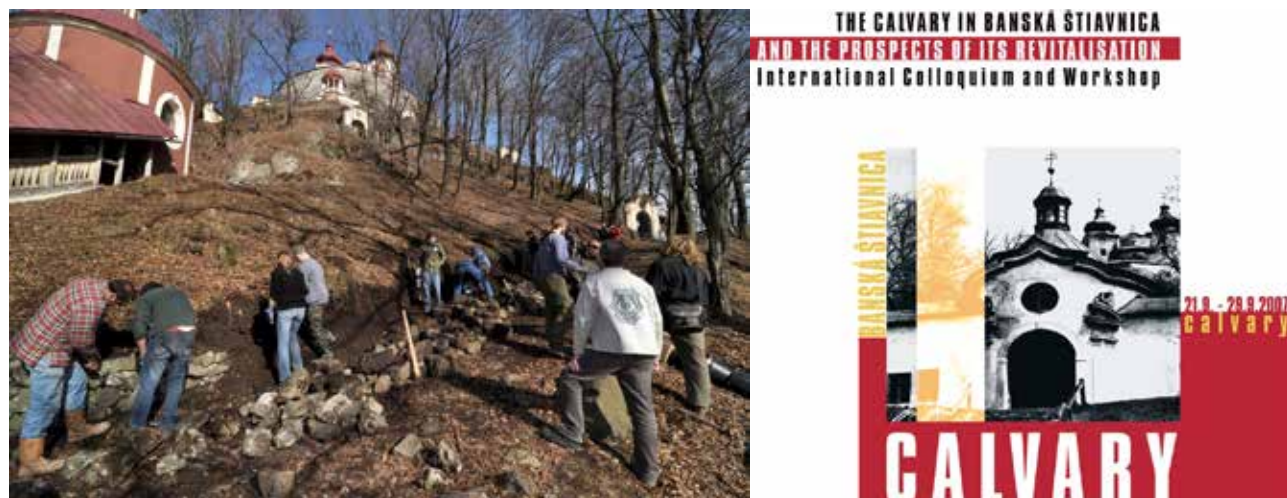


Fig. 9,10 International colloquium and workshop on preserving and revitalizing the Calvary, organized by the Faculty of Architecture and Design of the Slovak University of Technology in September 2007 and 2010. Photo by Lubomír Lužina.

dendrological (the original extent of the greenery of the architectural-landscape concept had been revealed); structural survey of the stone staircases and trusses of the towers and a number of smaller studies that ascertained the construction-technical condition, diagnosed failures and proposed solutions for restoration.

At the end of the research, which lasted for almost two years, a general architectural project for the restoration of the complex was prepared and a methodology for supplementing the missing Baroque parts and elements was determined consensually by members of a professional working group from various institutions in view of the degree of damage and missing parts of the sculptural decoration, taking into account the original iconographic concept.

The next step was the project implementation. The restoration of the Calvary has lasted 16 years, and work is still continuing to complete its original iconographic richness.

The Calvary Fund devoted itself also to systematic work with the public. Brigades were organized for the maintenance of the area, cleaning, small celebrations on the occasion of the completion of individual stages of restoration. Cooperation with the media played an important role in fundraising and in involving the local and entire community. The visibility and promotion of the professional restoration of a nationally significant monument meant an improvement in the public's relationship to the protection of cultural heritage.

As the final step, after the completion of the restoration of the complex, a sustainability plan should be established, focusing on financial self-sufficiency, and regular maintenance of the area.



Fig. 11,12 The Lower Church of the Calvary Complex before and after restoration. Archive of Authors.



Fig. 13 The restoration process accompanied by a discussion between experts – restoration of the frescoes in the Chapel of the Lower Church. Photo by Lubomír Lužina.



Fig. 14 - Ceremonial opening of the Upper Church and Holy Mass after the completion of the restoration, 2018..

Lesson learned and summary

The unique character of the Calvary is the reason for visits by numerous tourists and pilgrims from all over the world.

The timely mobilization of forces and the undertaken actions with carefully planned interventions on the basis of thorough research have significantly contributed to saving this valuable complex and preserving its authenticity. It was positive that the restoration did not take place spontaneously, but step by step according to pre-determined criteria, expert proposals following expert discussions. Crucial was the funding – financial grant to Faculty of Architecture and Design – for the scientific researches of the Calvary complex (granted by Foundation of Intesa San Paolo bank, VUB bank (2008 – 2009) and the financial grant for the most urgent fresco conservation in the Lower church – from World Monuments Fund, New York, USA (2008 – 2013).

In the case of the Calvary the rehabilitation process, restoration methodology and collaboration, joint forces of all stake holders allowed for a very positive result. It has been confirmed, that a dedicated process management, fundraising and leadership as well as the involvement of the local community and volunteers are very effective.

Nowadays, the Calvary is a lively place for religious services and pilgrimages, a popular tourist destination, a place for cultural events and school activities. A big challenge for the future is setting up a plan for sustainability and permanent maintenance of the buildings and grounds.

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THE RECONSTRUCTION OF BUDA CASTLE DISTRICT

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Abstract

The reconstruction of the Buda Castle District, severely damaged during World War II, provides an insightful example of urban and cultural recovery. Between November 1944 and February 1945, the district endured intense destruction due to air bombings, artillery, and street battles between Nazi and Soviet forces, leading to the death of 25,000 civilians and the loss of 27% of its buildings. Key structures, including the Royal Palace and numerous churches, were destroyed. The district, rich in medieval and baroque heritage, had previously suffered similar devastations during the Turkish occupation, but post-war efforts sought to restore its historical layers. Reconstruction, guided by a professional consensus, aimed to emphasize the medieval and baroque forms, incorporating archaeological findings. From the late 1940s to the 1980s, the efforts successfully revitalized the area, achieving UNESCO World Heritage status in 1987. However, since 2010, a new reconstruction initiative has shifted focus, favoring the revival of late 19th-century styles and undermining earlier cultural values. The lack of public participation in both reconstruction periods raises questions about the balance between professional expertise, historical integrity, and public engagement in urban recovery.

Socio-cultural context

The Castle District The reconstruction of the Buda Castle District, severely damaged during World War II, provides an insightful example of urban and cultural recovery. Between November 1944 and February 1945, the district endured intense destruction due to air bombings, artillery, and street battles between Nazi and Soviet forces, leading to the death of 25,000 civilians and the loss of 27% of its buildings. Key structures, including the Royal Palace and numerous churches, were destroyed. The district, rich in medieval and baroque heritage, had previously suffered similar devastations during the Turkish occupation, but post-war efforts sought to restore its historical layers. Reconstruction, guided by a professional consensus, aimed to emphasize the medieval and baroque forms, incorporating archaeological findings. From the late 1940s to the 1980s, the efforts successfully revitalized the area, achieving UNESCO World Heritage status in 1987. However, since 2010, a new reconstruction initiative has shifted focus, favoring the revival of late 19th-century styles and undermining earlier cultural values. The lack of public participation in both reconstruction periods raises questions about the balance between professional expertise, historical integrity, and public engagement in urban recovery.

Main data of the event: kind of disaster, intensity, interested area, lost heritage (people dead, buildings destroyed, etc)

Destruction of the urban and historic structures by war: heavy destruction by air bombings, heavy artillery and street fights between the Nazi and the Soviet forces

When: from November 1944 until February 1945.

Lost heritage: 27% of buildings destroyed, the Royal Palace burned out completely, many churches and palaces have been destroyed until the base walls.

People loss: 25 000 civilians dead, 52 000 wounded

Socio-cultural context

The Castle District is the civic historic neighborhood of Budapest, reminding the city of its medieval and baroque heritage and civic pride (Gerő, 1979). This district on the top of a large hill by the Danube was always a center, mainly for its defensive potentials, leading also to be the center of many destructions in wars. The largest was the destruction of the medieval and renaissance city during the sieges of the Turkish occupation in the 16th and 17th centuries. The baroque reconstruction gave a second golden age to Buda, while the

Dualist monarchy of the Austro-Hungarian Empire led to a race in monumentalism to show Vienna how governmental and monarchist constructions can be just as representative in the Castle hill as on the Ring of Vienna. Budapest suffered the longest siege after Stalingrad in Second World War, 100 days of heavy fights lead to the destruction of one third of the city, and the Castle District of Buda suffered the most, as it was the last retreat of the Nazis. The reconstruction started slowly, but with the capitalized property ownership and central planning and construction a full reconstruction could be done between 1949 and the early 1980s (Gerő, 1982). However, this period of reconstruction declared the buildings erected in the late 19th early 20th century out of scale and context, therefore these have been transformed to smaller scale modern reinterpretations or new modern infill buildings have been constructed in their places, while from 2010 the political atmosphere in Hungary changed in favor of the eclectic image of the pre-war Buda Castle, and a large scale reconstruction have begun, fueled by German examples and monarchist nostalgia. The understanding of the various layers of history and the motives of the various reconstruction periods can help to understand why reconstruction after a disaster leads to dangerous cultural choices affecting the notion of authenticity, but also that of livability and long term social and environmental sustainability (Zsebery & Toshikj, 2019).

Method of reconstruction

After World War 2 the first years passed with cleaning up the derbies, and at the same time the archeological surveying could start. The heavy damages caused by the war opened up new possibilities to research the history of the castle district, every layer of construction could be revealed. The scientifically based history of Buda could be written based on the valuable archeological sites opened piratically in every plot of the district. The medieval construction periods have been revealed, many original details from this period have been found under the plasters and new additions of later centuries (Katalin, 1972). The scientifically based need to show all valuable traces of the two main golden ages of Buda – medieval an Baroque – met the political desire to criticize the dualist and pre-war political system and its built representations, therefore the dictatorially imposed communist regime agreed with professionals in archeology and architecture on the main principles of the reconstruction. According to these most of the out-of-scale constructions of the late 19th and early 20th century were demolished or redesigned to a smaller scale and more modest ornamental appearance. The baroque and medieval urban form was respected and all original structures and ornaments from these periods have been showed, even at the cost of showing architectural details on facades that did not fit the composition of the building standing in its form from later historical periods. All new constructions had to fit in the original urban form, incorporation whatever remained from earlier times (e.g. cellars, gates and base walls). A unified coloring scheme has been applied to all buildings, evoking the baroque atmosphere of the district. The historical reconstruction process was conducted in the highest professional level, recognized by the international professional community and by the UNESCO World Heritage status in 1987.



Fig. 1 - The heart of Buda Castle District with streets reconstructed in the post-war period and public buildings under reconstruction in 2023. (Bálint Kádár)

For new buildings initially a very modest approach was taken, adopting the building forms and opening structures from the two highlighted historical periods, but without any decorations. This approach was criticized already in the 1950s, stating that it will lead to a dull uniformity. Therefore starting with the late-modern architectural movement of the early 1960's the best designers could create more and more modern buildings with surprisingly innovative housing models and building structures, but these always had to respect the historical urban context, not only by incorporating all archeological remains on the plot, but also by following a principle that can be identified as "fitting the surroundings", setting the roots to a new "contextualism", defining the work of many contemporary architects up till today.

Such architectural attitudes have been also applied to the late-baroque composition of the Royal Palace and surroundings. From 1949 László Gerő – the architect leading the reconstruction process - and colleagues revealed all medieval layers of this part of the castle, largely covered by new constructions of the Habsburg period. Bastions and fortifications have been reconstructed, sometimes following a speculative historical design as no original plans have survived. The bottom floors of the Royal Palace have been also reconstructed in their medieval forms as much as possible, creating an interesting tension between baroque and gothic or renaissance building structures. The baroque wings of the palace have been only reconstructed in their main aspects, adding non-decorated windows and a completely new cupola, as the pre-war form was retained to be un-historic due to the eclectic architecture used by Alajos Hausmann combining baroque with early secession motives in his final design from the turn of the 19th-20th centuries. The new dome was designed for a decade by the best architecture historians until it gained its baroque form resembling a Brunelleschi era construction fitting very well the baroque palace. The interiors of the palace were completed in the 1960s in a very modern style, resulting in impressive museum spaces.

Such reconstruction process was finished in the 1980's, and after the end of communism and the many political changes of the end of the 20th century a new debate has started on how to update Buda Castle, how to finish the only part remained unused after the World War, between the Royal Palace and the civic district. Archeologists could finish to survey the remainings of the 13th century civic town that was replaced by large built compositions after the Turkish occupation of the 16th – 17th centuries. However, the stabile right wing government formed in 2010 proclaimed a new reconstruction process that did not continue the principles respectful to medieval and baroque periods, but claimed to reconstruct the heritage of the late 19th and early 20th centuries. The Hausmann program was not timid in its ambitions to bring back all constructions standing in the castle in 1914, even though most professionals raised their voice against re-building some of the over-scaled buildings not representing any architectural value, not even in the context of late 19th century art and architecture. Construction started without financial limits, most of the old-new buildings started to be constructed with a concrete shell insulated and then decorated with as-it-was ornaments. Many archeological sites have been destroyed and many of the valuable but still unprotected 20th century modernist architectures was erased. The representative attitude of the large-scale governmental buildings suppressed the medieval and baroque heritage of Buda's historic center once more after 100 years (Alföldi, 2022).

Population involvement

The lack of social participation is connecting the long decades of reconstruction in the Buda castle. Still, after World War 2 all reconstructions were conducted according to wide professional consensus and even many professional debates, bringing the optimal solutions (like in the decade long design process of the dome of the Royal Palace). As opposed to this the new Hausmann program since 2010 bought an almost complete consensus among archeologists, art historians and architects that this present reconstruction is professionally wrong.

What connects the two reconstruction periods is the lack of public involvement of any kind, but also here there is a great difference. It must be stated, that the first decades of reconstruction could be so successful and comprehensive because the state in its communist dictatorship ceased any rights to private property in this district, capitalizing all buildings and excluding any private interest from the reconstruction and building processes. This way the property rights and decision rights were all in one hand for all buildings and spaces, therefore a unified methodology could apply, making the quality and comprehensiveness of the reconstructions in Buda, Sopron, Keszthely and Győr admired by professionals from western European countries, where such complete reconstructions were hard to achieve in a market le environment. Such centralization could have led to very bad results as well, but the state decided to reconstruct the Castle district according to some very positive goals: 1) to create a livable neighborhood with new housing, schools, services for the population. 2)

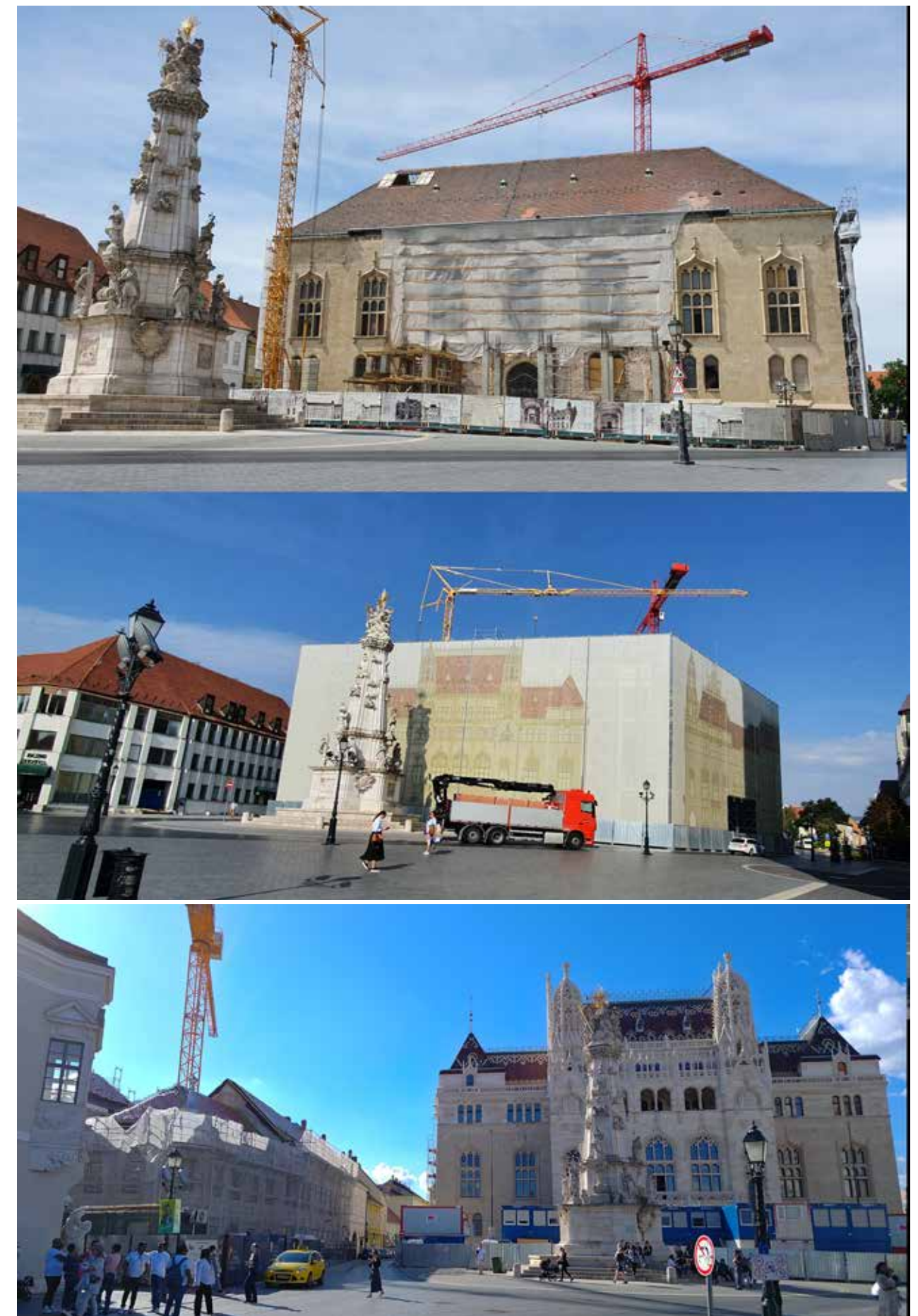


Fig. 2 . Phases of the reconstruction of the Ministry of Finance palace and the demolition of the Diplomat's house building as part of the Hausmann project (2020-2024, Bálint Kádár).

to bring cultural institutions to the larger buildings (like the Royal Palace itself), including museums, the National Library, scientific research centers, making the castle district a true cultural district. 3) to present in a comprehensive way the place and the history of Buda to tourists, keeping a unified design, information system, establishing restaurants and bars and even a large Hilton hotel in the place of the Dominican convent. Such principles led to an attractive cultural district, that was primarily kept as a living neighborhood, improving the quality of life to many living there and creating contemporary housing forms for many more. Society was not asked or involved, but its needs have been largely integrated (Gerő, 1980).

The Hausmann project since 2010 is completely different in its goals. The Castle District is being deprived of most of its cultural and scientific functions, and many representative functions are planned instead. Government buildings, seat of the prime minister and president, ministries take over cultural functions. The local population is no longer a target group, no developments aim the quality of living of locals, and not one new apartment have been designed in the many and large reconstructed buildings. The society once again is not asked, no form of public participation took place, but the advertisement of the project and the political message could keep large social critiques away. In fact the main message is to re-give national pride and grandeur to the castle, to “fix” the wounds of World War definitively and to also “fix” the brutalist modern interventions by demolishing buildings still considered ugly by society and replace them with well decorated replicas. Such actions resonate with the majority of society, while the local population is less than 2000 today, also manipulated politically. Therefore the project resonates with the nostalgia and nationalism of the population, comfortably avoiding any forms of participation in the reconstruction process.



Fig. 3 Tourists trying to interpret the ruins in St. George square in the Castle District before the works of the Hausmann project reconstruction. (Bálint Kádár)

Conclusions (lesson learnt)

Wars did cause enormous loss of values and did alter the urban form and functions of cities. The Castle District in Buda suffered many times in history, losing its medieval and renaissance splendor in the 16th century, and losing much of its baroque and historicist splendor in World War 2. However, even the reconstruction processes did lead to some loss many times. In the late 19th century the baroque aesthetic and scale of Buda was replaced by a grandiose representation will to make this a center of Hungarian governance and pride. Most of this was dismantled in the reconstruction process between 1945 and the 1980's, giving back the scale and aesthetics of medieval and baroque times, but also giving a strong cultural function and a livable neighborhood to the district gaining World Heritage status from UNESCO. The Hausmann project from 2010 aimed to finish the post war reconstruction definitively, but by building replicas of 100 year old buildings it willingly aims to set back the cultural functions, the living qualities and 800 years of historical layers of the site.

Public participation was not an agenda in the reconstruction processes during state socialism, however, they could have been in the new process since 2010. It is an important lesson to learn how a centralized power can successfully avoid public participatory processes by using the general nostalgia, nationalism and low levels of architectural education of the population. A more sophisticated, professionally sound and socially beneficial reconstruction process can be possible only if populism can be balanced with good educative programs, a strong voice of professional organizations, and first of all the real willingness to create a participatory process.

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RECONSTRUCTION OF RESIDENTIAL AREAS DEVASTATED BY THE TOXIC RED SLUDGE DISASTER

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Abstract

The reconstruction of the Buda Castle District, severely damaged during World War II, provides an insightful example of urban and cultural recovery. Between November 1944 and February 1945, the district endured intense destruction due to air bombings, artillery, and street battles between Nazi and Soviet forces, leading to the death of 25,000 civilians and the loss of 27% of its buildings. Key structures, including the Royal Palace and numerous churches, were destroyed. The district, rich in medieval and baroque heritage, had previously suffered similar devastations during the Turkish occupation, but post-war efforts sought to restore its historical layers. Reconstruction, guided by a professional consensus, aimed to emphasize the medieval and baroque forms, incorporating archaeological findings. From the late 1940s to the 1980s, the efforts successfully revitalized the area, achieving UNESCO World Heritage status in 1987. However, since 2010, a new reconstruction initiative has shifted focus, favoring the revival of late 19th-century styles and undermining earlier cultural values. The lack of public participation in both reconstruction periods raises questions about the balance between professional expertise, historical integrity, and public engagement in urban recovery.

Method of reconstruction

On October 4, 2010, Hungary experienced an unprecedented ecological disaster when a tailing dam at an alumina factory broke, releasing one million cubic meters of toxic red sludge into the villages of Kolontár, Devecser, and Somlóvásárhely. The disaster caused 10 deaths, 123 severe burn injuries, and damaged over 300 houses. The government declared a state of emergency and allocated 38 billion forints for reconstruction. The process was expedited by legislative changes allowing fast-track approvals. However, contamination and psychological trauma prevented rebuilding on much of the original site. Only 110 houses were rebuilt, with some residents opting to relocate. Involvement of residents in the design process was key to regaining trust, but social and psychological challenges remain. This experience highlighted the need to combine physical reconstruction with social and psychological support for true rehabilitation.

Main data of the event:

Kind of disaster: Toxic red sludge disaster

When: 04. October 2010

Lost heritage: More than 300 houses were damaged.

People loss: 10 residents dead, 123 people suffered serious burns.

On 4 October 2010, Hungary's biggest ecological disaster occurred. The events were not without precedent. During the industrial tragedy caused by human error, the tailing dam of the alumina factory of the Hungarian Aluminium Production and Trading (MAL Zrt.) Company broke through, and deeper parts of neighbouring Kolontár, Devecser and Somlóvásárhely were flooded with more than a million cubic metres of alkaline water and a mixture of toxic red mud. 10 Kolontár residents lost their lives and 123 people suffered serious burns from the highly corrosive substance.

More than 300 houses were damaged in the three affected settlements – with a combined population of nearly 6500 people – more than 80% in Devecser. The majority of them had to be demolished, and the damage to movable and immovable property amounted to one billion forints.

The spilled red sludge poisoned about a thousand hectares of land in the Ajka region, then diluted and flowed through the Torna stream into the Marcal River, the Raab River and finally into the Danube, creating an international emergency. (Fig.1-2) The wildlife of the Torna and the Marcal died out, while the Moson-Danube was protected by reducing the alkaline chemical effect.



Fig. 1 Location of the municipalities affected by the disaster (source: own map based on OpenStreetMap)



Fig. 2 Satellite image of red sludge contamination 5 days after the disaster (source: Jesse Allen - NASA Earth Observatory)

Method of reconstruction

The tragedy received a lot of publicity in the Hungarian press and from the very beginning it was the focus of increased state attention. On the very next day, the government declared a state of emergency in the three affected counties (Veszprém, Vas and Győr-Moson-Sopron), and the damaged settlements were closed, an evacuation plan was drawn up and the disaster was localised by the construction of protection works. (Fig.3-4).



Fig. 3-4 Traces of red mud on the wall of a house in Kolontár and its surroundings (source: Csóka, 2021a)

According to the Prime Minister's announcement in the first week - that the state will not treat the issue of recovery as an insurance matter, but takes it upon itself to manage it and provide compensation to the affected parties from budgetary resources - he made it clear that the operational tasks related to the recovery will also be centrally managed. It became a priority for the state to ensure that the housing conditions of the victims are met as quickly as possible (Tax, 2011; Interview 1). A total of 38 billion forints were spent on restoring the damage - including 21 billion forints for environmental elements - an important component of which was the compensation of civilians who were forced to demolish their homes due to the physical deterioration caused by the disaster. Thanks partly to centralised management and partly to the legislative environment, the first public procurement was completed within three months and the first house was rebuilt. During this time, the selection of the required land, the purchase, the land reclamation, public utilisation and pre-development, the regulatory and architectural planning process for the new constructions have been done in fast-track, as well as carrying out their official approval tasks. None of this would have gone so smoothly had it not been for another (natural flooding) disaster in Hungary a few months earlier, whose experience was incorporated into the management of the post-red mud reconstruction process. The problems encountered highlighted that exceptional measures and concerted action in emergency situations require specific procedural order and are difficult to integrate into building legislation designed for general situations. (Szaló et al, 2011; Interview 1.) This has encouraged stakeholders to create a legislative environment that allows for a more flexible procedural regime in certain situations such as any mass casualty event.

In order to simplify the procedures, the Building Act was amended and the Government Decree on exceptional construction rules related to the repair of damage to buildings caused by an emergency situation was promulgated. This provided, inter alia, for a shortening of the consultation process for the urban planning instruments that create the conditions for construction, the halving of the time needed to complete authorisation procedures (30 days), which could be even further halved if the recommended architectural technical plans are used. The demolition, building, occupation and maintenance permits became immediately enforceable, regardless of the appeal (Szaló et al, 2011). The traditionally much longer procedure thus took precedence everywhere, both from a legal and humanitarian point of view, and was therefore much faster than usual.

The main coordinator of the remediation, rescue and restoration works was the National Directorate General for Disaster Management under the Ministry of Interior, but also a number of employees of the Ministry of Interior, researchers from the Hungarian Academy of Sciences and university lecturers were involved in the organisation and implementation of the various work areas. The Minister responsible for construction has appointed a Special Commissioner for Construction to manage and coordinate damage assessment, demolition and reconstruction, who involved ÉMI Nonprofit Company and the Hungarian

Chamber of Engineers, and organised an expert group to investigate building damage. The Government Coordination Centre for Reconstruction operated by the Disaster Management was responsible for the appropriate local control and execution of the works for almost a year, 24 hours a day. It operated several working groups (operational control, legal, reconstruction, logistical), supported by the police, the fire brigade, the national defense, the capital, the local government and several civil and professional groups (Tax, 2011).

Never before had this type of disaster occurred in the world (Szaló et al, 2011), so there were no process experiences of precedent value to draw from in the field of damage assessment. On-site and laboratory tests have shown that the vast majority of the flooded areas are no longer suitable for housing, and after the demolition of the buildings the reconstruction as residential area cannot be recommended (Szaló et al, 2011). There were several arguments against rebuilding on the original site; mainly the contamination of the area, but at least as much a question of people's sense of security, the aspects of processing the trauma experienced connected to the given place (Csóka, 2021a). Instead of the approximately 250 houses that were demolished, only 110 had to be built (21 Kolontár; 89 Devecser; 1 Somlóvásárhely; 1 Márkó) since only so many wanted to start their lives locally, in the newly developed area. The possible damage mitigation options included an annuity, buying property elsewhere, and occasionally lump-sum compensation, so not everyone wanted to stay put. (Interview 1.)

The designation of the new residential areas was essentially determined by practical considerations; the existing town planning framework, dimensions and land value, ownership structure and accessibility. While in Kolontár, the new residential areas were integrated into the existing settlement structure as a continuation of an existing street (Bezerédy street), in Devecser, a new 10-hectare area was designated for this purpose on the edge of the settlement, on the site of a former arable land (Fig.5-6).



Fig. 5-6 Street views of Devecser and Kolontár in 2021 (photos: Tamás Szántó; source: Csóka, 2021b) .

Population involvement

Public information forums have been organised since the beginning of the reconstruction process, partly by the Ministry of the Interior and the General Directorate of Disaster Management - which organized the entire process -as well as by local governments. Nevertheless, there was a lot of mistrust for a long time. The population composition of the affected settlements is very diverse, perhaps this explains why, despite the common tragedy, the information was provided separately for them and there was no subsequent effort to organise coordinated joint events, either by the locals or by the different helpers from different knowledge fields from outside. Clearly, those who suffered not only material but also personal loss were affected to a different degree. In this respect, although fewer properties were destroyed in Kolontár, all family tragedies occurred here, thus, in this settlement, the mistrust of the locals of various bodies, planners and aid providers was most significant (Interview 2).

The involvement of the Kós Károly Association (an intellectual and professional association of several architectural firms) [1] opened a new chapter in the process of consultation and communication with the local

[1] <https://koskarolyegyesules.hu/>

population, who were already in a close cooperative relationship with the General Directorate of Disaster Management in connection with the reconstructions after the previously mentioned flood disaster. (2001./Bereg; 2010.július/ Felsőzsolca) The coordinating architects (Attila Turi, László Zsigmond) collected information on the traditional local construction method, building style, morphological and settlement characteristics, traditional street pattern, architectural character, patterns and typical materials in the area and in its surroundings. All of their findings were defined as a kind of recommendation and instruction in the in-house tender that was issued for the members of the Károly Károly Association in connection with the reconstruction case.

In the process, it was essential that a previously tried-and -tested “scenario” already existed, and an organisation already experienced in handling empathic communication and participatory planning with a population that was distrustful because of its vulnerability. The initial mistrust of people is also reported by architects and planners (Csóka, 2021a). The weekly meetings began to overcome the initial suspicion when the personalised consultations started about who wanted to build their new home, where, on the basis of which type of plan and with which changes. A further significant breakthrough on trust-building came when the victims were taken to visit rebuilt houses in one of the former disaster areas in Bereg, where the people concerned “...found a common voice with the locals based on a shared fate, an experienced tragedy” (Csóka, 2021a). The demolition of properties that became life-threatening meant special mental trials for the population, thus – for the spiritual protection of the locals - the media was kept away from the demolition work. Thanks for these, as well as with the construction and presentation of the first new house, the victims have continued to open up to the designers.

The designers wanted to combine the practicalities of prefabrication and organisability with the unique needs dictated by different living and family situations. Great emphasis was placed not only on personality, but also on the understandable communication of the designer’s intentions. Separate presentations, printed design catalogues and a website helped to understand how the new houses work. Furthermore, in order for the new buildings to have more significance for the victims, each family could incorporate a brick from their demolished home into the wall of their new property, thus trying to preserve their local identity and their attachment to the place.

The communities affected - socio cultural context

Social, individual and community resilience as well as regenerative capacity in the face of major negative events, including man-made industrial disasters, is now a widely researched topic. Securing and maintaining them in a stable way should be one of the most important political tasks. During disasters, social systems that become fragile, disintegrate or are possibly destroyed are at significant risk, a chaotic situation that can be addressed by state intervention, by artificially maintaining existing processes. In the case of the red sludge disaster, state intervention did take place, but since the concept and importance of community and individual resilience in the field of crisis response is even less known in Hungary, psychological intervention attempts on the part of the decision-makers were only given a very small chance, so their effectiveness could not be adequate (V.Komlósi - Richter, 2015). Although employees and volunteers from several aid agencies (health, food, charity,

pastoral care, etc.) assisted in the rehabilitation work, in general the interventions focused mainly on restoring the physical environment and only secondarily on addressing the social, community and individual psychological problems that arose. As a result, many of the victims are still vulnerable today (Bartal - Ferencz, 2015).

Not only the red sludge disaster itself, but also the guided post-disaster interventions had an impact on the lives of the affected communities, as we have to take into account their unintended consequences, whether positive or negative. Examples of positive impacts include the strengthening of cohesion between people, solidarity, community collaboration, or community empowerment. It is a proven fact that the effects of extreme stress (disaster situations) can be mitigated if the people affected are mutually support each other. In the case of the red sludge disaster, the strength of unity within the individual settlements that suffered damage was relatively good, but unfortunately there was no cooperation between municipalities. This was also reinforced by the fact that the centrally organised rehabilitation work in each settlement (and even for each individual victim) was treated completely separately because of the socio-community differences between them (Bartal-Ferencz, 2015; V. Komlósi - Richter, 2015; Interview 2).

The negative consequences of controlled interventions can be the emergence of tensions within or between settlements, the raise of envy and strife, the division of the population, and the loss of trust. There are significant differences in the social/community processes in the settlements affected by red sludge. Devecser had relatively stronger settlement ties among the victims. After the reconstruction: “We know everyone in the new residential complex by sight, of course, but friendships do not form here” (Bartal-Ferencz, 2015 p.150.). At the same time, it says a lot that the newly developed part of the settlement is called a residential complex, which in Hungarian is often synonymous with enclosed areas that are isolated from their surroundings, both in terms of their operational system and the attitudes of their inhabitants. One of the main disadvantages of the new Devecser area is that it could be significantly isolated from the centre. (Fig.7)

Several deaths occurred in Kolontár as a result of the disaster, so the attitude and trust of the people living there towards the remediation and rehabilitation workers was more negative than in the other affected areas. This, on the one hand, made it difficult to intervene effectively and on the other hand to keep the inhabitants of the settlement and the victims “under control” and assist them. As a result, the negative effects of managed interventions were more pronounced here (Bartal-Ferencz, 2015; Komlósi-Richter, 2015; Interview 2). The situation was made controversial by the fact that there were many families among the victims who were put in a better position as a result of reparations; therefore, some local people who were not or had little damage felt a certain amount of envy towards them, considering that they could not get a newly built house (Interview 2).

A nice idea in Devecser was the creation of a park on the site of the damaged area to commemorate the disaster (Fig. 8), which, despite the tragedy, sends a positive message to locals and visitors: “with cooperation there is a way out of even the most difficult situations” (Szaló, P. 2011). However, more than 10 years after the disaster, community development and talking about community problems would still be an important task. Because, in contrast to the rapid physical recovery, the healing and rebuilding of a traumatised mental and social system requires significantly more time and energy.

Conclusions (lesson learnt)

The process of reconstruction related to the red sludge disaster offers internationally relevant experience in many aspects. First of all, in terms of the actors participating in the process and the roles established between them, the active cooperation with the locals and the quality and sensitivity of communication. The victims and the local people not only received help, but were able to be part of the rebuilding process. They were put in an active role, by giving them specific tasks and thus contributing to the psychological process of processing the tragedy. The management of the design of building types, the opportunity of choice made by the residents and their adaptation to individual family situations can also be considered as a success story. However, a number of doubts may also arise, especially from the aspect of community building and community recovery, the positive outcome of which does not automatically occur as a result of helping individuals, families or the successful reconstruction of a part of the settlement. Rehabilitation that is successful in all respects puts as much effort into rebuilding the lives of local communities disrupted by a given disaster as it does into restoring the physical environment. This includes community strengthening methods and processes facilitated by a professional. In addition, the careful urban designation of new residential areas from an urban planning point of view, taking into account settlement integration, and the acceptance of the new settlement part by the population, both those who are moving in and those who are not, can also help.



Fig. 7-8 The edge of the new residential area in Devecser (source: the authors); Devecser - Memorial Park (source: <https://www.devecser.hu/devecseri-emlekpark>) .

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POST-EARTHQUAKE RECONSTRUCTION IN THE HISTORIC CENTER OF L'AQUILA: STRATEGIES, METHODS, INTERVENTIONS

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Abstract

The 2009 earthquake in L'Aquila devastated the city's historic center, requiring a multifaceted reconstruction effort. The primary goal was to restore both the urban and social functions of the area while preserving its historical and cultural value. This involved a collaborative process with public institutions, experts, citizens, and local associations. Key strategies included participatory planning, sustainable practices, and the use of innovative technologies such as BIM for effective project management. Structural consolidations and the restoration of cultural landmarks were prioritized. Additionally, psychological support for the affected population and economic recovery initiatives were crucial. The reconstruction process integrated advanced techniques with traditional methods, ensuring the preservation of artistic heritage. The revitalization of public spaces and the promotion of tourism helped reintegrate the population. L'Aquila's recovery serves as a model of resilience, demonstrating how disaster can lead to cultural and social regeneration, emphasizing the importance of community involvement, innovation, and sustainable development.

L'Aquila: Strategies, Methods and Interventions

The earthquake that struck L'Aquila on April 6, 2009, had a devastating impact on the city's historic center (Fig. 1), leaving a vast area in a state of severe damage (Fig. 2). The reconstruction of the historic center has been a complex challenge that required a combination of innovative strategies, scientific methods, and targeted interventions. This process involved a plurality of actors, including public institutions, sector experts, citizens, and local associations.

One of the primary objectives of the reconstruction was to restore the urban and social functionality of the historic center while preserving its historical and cultural value (Fig. 3). The strategies adopted included participatory planning, which involved the local community to ensure that the decisions made met the population's needs. Through public assemblies, meetings with residents, and consultations with experts, it was possible to outline a shared plan for the future of the city. Additionally, priority was given to historic buildings with targeted interventions to consolidate and restore structures of particular importance, such as churches, historic palaces, and monuments (Fig. 4, 5). Sustainability and innovation played a fundamental role in the reconstruction, which was oriented toward sustainable solutions using environmentally friendly materials and techniques while promoting energy efficiency. Advanced digital tools such as Building Information Modeling (BIM) were adopted to improve the planning and management of the works.

The reconstruction process was based on a combination of traditional and technologically advanced methods. Damage mapping was carried out immediately after the earthquake using drones, laser scanners, and photogrammetry techniques to get a clear view of the situation and plan interventions effectively. The buildings were subjected to thorough investigations to assess structural stability and identify critical issues through methods such as dynamic analysis and non-destructive testing. Restoration interventions were carried out following conservation principles, using techniques compatible with the original materials. For example, frescoes and decorations in churches were restored with non-invasive methods. Furthermore, digital platforms were used to manage information related to the interventions, ensuring greater transparency and better coordination among the various actors involved.

Numerous interventions have been carried out to revitalize L'Aquila's historic center. Structural consolidation involved many buildings, reinforced with innovative materials such as carbon fibers and high-strength steels to improve their ability to withstand future seismic shocks. The restoration of artistic heritage brought back significant historic buildings to the city, such as the Basilica of San Bernardino, the church of Santa Maria del Suffragio, the Cathedral, and the Fountain of the 99 Spouts. These interventions have allowed the recovery of some of the city's most symbolic landmarks. Public spaces such as squares, streets, and gardens were redeveloped to create welcoming and functional environments, encouraging the return of the population and promoting social interaction (Fig. 6, 7). To support economic recovery, incentives for

commercial and artisanal activities were created, and cultural events were organized to attract visitors and revitalize tourism. Finally, modern infrastructure, such as advanced communication networks and sustainable mobility systems, were implemented to improve residents' quality of life.



Fig. 1 L'Aquila on April 6, 2009, had an earthquake with a devastating impact on the city's historic center.



Fig.2 The earthquake produced a severe damage in the city.



Fig. 3 One of the primary objectives of reconstruction was to restore the urban and social functionality of the historic center while preserving its historical and cultural value. Piazza del Duomo.



Fig. 4 Reconstruction priority was given to historic buildings with targeted interventions to consolidate and restore structures of particular importance, such as churches, like Chiesa di Santa Maria Paganica.

In addition to technical aspects, it was essential to consider the human side of the reconstruction. The earthquake caused significant trauma to the local population; many people lost family members, friends, and their homes. For this reason, a psychological and social support process was initiated to help citizens overcome the trauma and regain a sense of community. This was achieved through group activities, cultural events, and training programs aimed at encouraging people to return to the historic center.

Another essential element was the recovery of the city's economic fabric. L'Aquila has traditionally been a center of craftsmanship, commerce, and tourism, which suffered a severe blow due to the earthquake. Economic recovery plans included tax incentives for businesses, subsidized loans, and tourism promotion campaigns. The university sector also played a crucial role. The University of L'Aquila was at the center of many research and innovation initiatives, contributing not only to reconstruction but also to creating new development opportunities for the city.

The management of financial resources was another critical aspect of the reconstruction. The Italian government, the European Union, and other international organizations allocated significant funds, but strict control over their distribution was necessary to avoid waste and ensure they were used efficiently. Transparency was ensured through the use of digital platforms, which allowed citizens to monitor project progress and report any problems.

The reconstruction process in L'Aquila also faced challenges related to bureaucracy and the need to coordinate a large number of actors involved. Public institutions, private companies, non-governmental organizations, and citizens had to work closely together to overcome obstacles and ensure the project's success. This experience led to greater awareness of the importance of streamlining bureaucratic processes and promoting collaboration across different sectors.

Despite the difficulties, the case of L'Aquila represents a positive example of resilience and the ability to turn a crisis into an opportunity for growth and development. The city was able to reinvent itself by enhancing



Fig. 5 Reconstruction priority was also given to squares and streets.



Fig. 6 Public spaces reconstruction, such as buildings, was developed to create hope for a welcome and functional environment.



Fig. 7 Public spaces such as squares were redeveloped to create welcoming and functional environments, encouraging the return of the population and promoting social interaction.

its cultural and historical heritage and integrating it with technological and social innovations. Today, L'Aquila is considered a model for other cities facing similar challenges, demonstrating that with a strategic vision and collective commitment, it is possible to overcome adversity and build a better future.

L'Aquila's historic center today is a place of memory and rebirth. Its restored streets, squares, and buildings tell a story of resilience and hope (Fig. 8,9). The reconstruction has not only recovered the architectural heritage but also created a more inclusive, sustainable, and livable city. This process has demonstrated that reconstruction is not just a technical issue but also an opportunity to rethink the future of a community by valuing its roots and looking forward with confidence.



Fig. 8 One of the streets after the earthquake.



Fig. 9 The same restored street tell a story of resilience and hope.

The post-earthquake reconstruction in the historic center of L'Aquila represents a significant example of how a territory can be reborn after a tragedy. The strategies adopted, the methods used, and the interventions carried out have transformed an emergency situation into an opportunity to build a safer, more sustainable, and more livable city. This process can serve as a model for other areas affected by similar events, highlighting the importance of an integrated and participatory approach in emergency management and reconstruction planning.

Today, L'Aquila looks to the future with a new vision that combines tradition and modernity. The city has launched urban and cultural innovation projects, promoting initiatives related to digitization, environmental sustainability, and the enhancement of local resources. The historic center has become an open-air laboratory where new urban and social solutions can be experimented with, without forgetting the lessons learned from the 2009 tragedy.

In this context, community participation continues to be a key element. Citizens are involved in decision-making processes concerning urban planning and economic development, strengthening the sense of belonging and social cohesion. Cultural events, exhibitions, and festivals celebrate the city's rebirth, attracting visitors from all over the world and contributing to relaunching L'Aquila's image as a center of cultural and tourism excellence (Fig. 10).

L'Aquila's reconstruction journey highlights how it is possible to turn a catastrophe into an opportunity for growth through a combination of innovation, resilience, and collaboration. The historic center is now a symbol of rebirth that tells a story of courage and determination, an example for other communities facing similar challenges, demonstrating that reconstruction is not only about the physical recovery of buildings but also about regenerating the social, cultural, and economic fabric of a city.

Looking to the future, L'Aquila continues to invest in sustainable development projects aimed at creating a more inclusive and resilient urban environment. The city is committed to becoming a reference model for emergency management and post-earthquake reconstruction, offering a concrete example of how cooperation between institutions, citizens, and the scientific community can lead to extraordinary results.



Fig. 10 Cultural events, exhibitions, and festivals celebrate the city's rebirth, attracting visitors from all over the world and contributing to relaunching L'Aquila's image as a center of cultural and tourism excellence. The Spanish Fortress.

The story of L'Aquila's reconstruction is a testament to how collective will can overcome adversity, turning difficulties into opportunities for growth and innovation. The historic center today is not only a place of memory but also a symbol of hope and future, an example of how a city can rise from its ashes and look forward with confidence, determination, and a sense of community.

L'Aquila's future is now a positive narrative of innovation, resilience, and sustainability. The city has developed new expertise in urban planning and emergency planning, becoming a reference point for other areas. The commitment to using advanced technologies has improved prevention and risk response capabilities, contributing to creating a safer and more cohesive community. The enhancement of cultural and natural resources has been at the heart of development policies, highlighting the territory's peculiarities and attracting investments and interest on an international level.

The reconstruction has also highlighted the importance of dialogue between past and future, integrating modern solutions while respecting historical heritage. L'Aquila has become a laboratory where tradition and innovation meet, a concrete example of how cities can face the challenges of the 21st century. Education and training have been key elements in raising citizens' awareness and preparing them to actively participate in building their future.

Today, L'Aquila is not only a symbol of rebirth but also a city that looks to the future with confidence. Its experience demonstrates that challenges can turn into opportunities and that resilience is not only the ability to withstand but also to evolve and grow. The city represents an inspiring model for all communities facing difficulties, showing that with commitment, collaboration, and vision, it is possible to build a better and sustainable future.

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RIVER FLOOD IN PRAGUE 2002

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Abstract

The devastating flood in 2002 in Central Europe is an example, which has been analysed in detail and provided stakeholders with useful lessons. The August 2002 flood was one of the biggest natural disasters on the territory of the Czech Republic during past few centuries. The chapter describes its impact on urban areas and in detail the devastating effect on monuments and cultural heritage objects and artefacts. The course of the flood is monitored through the impact on cultural life and society in Prague and more in detail in small neighbourhood of Prague-Troja Municipal District. The roles of citizen and Flood Committee are described to give an example for future improvements in management practices during and after the flood. Methods of reconstruction reflect different approaches applied in the Karlín District, Prague-Troja and cover also protective measures, which have been materialized after the catastrophic event to improve the protection of inhabited areas of the city. The involvement of population and regular training of different stakeholders is promoted to improve the knowledge and preparedness for disaster situation in place. Concluding notice stresses the need to reduce the risk of loss of cultural heritage through the set of actions, which would prevent disastrous negative cumulative effects of wrong decisions in management, the poor physical condition of monuments, evacuation failures as well as non-professional restoration and reconstruction works applied after the flood.

Main data of the event

The devastating flood in 2002 in Central Europe is an example which has been analysed in detail and provided stakeholders with useful lessons. The August 2002 flood was one of the biggest natural disasters on the territory of the Czech Republic during past few centuries. It hit mainly the Vltava (Moldau) River Basin and the Labe (Elbe) River downstream of the Vltava tributary. The damage caused by the August 2002 flood to properties has been estimated at CZK 73.14 billion (EUR 2.6 billion); there were 19 casualties; and a total of 968 agglomerations and 3.2 million people were afflicted (Ministry of environment of the Czech Republic, 2004). Return periods of maximum flows on many measured profiles exceeded 1000 years. According to the Czech hygiene station in the morning 14. August 2002 the flow volume in Prague exceeded 5300-5500 m³/s and in the afternoon the flood maximum culminated about 5700 – 5800 m³/s, according to some entries the maximum reached even more than 6000 m³/s (Sobota, 2003). The 2002 flood severely damaged not only the houses and infrastructure but also numerous cultural heritage objects, architectural, artistic and written documents and drawings. As far as the damage on monuments is concerned, the ministry of culture reckons the loss of about EUR 86 million in its first assessment (Ministry of environment of the Czech Republic, 2004). But this first estimation actually underestimated the real loss on cultural heritage, which could appear later. The illustrative examples below show some typical damage in the Czech Republic by the floods in 2002. It was the one of the biggest floods, which Prague survived. The city government was not prepared for such a catastrophe, hydrological estimates totally failed, and residents were informed about the extent of the danger in a very distorted way, which led to more damage than necessary. Large areas in the centre of Prague were flooded. The garden of the baroque Prague Troja Château changed into a lake (Fig. 1). The Troja district damage and post flood activities are further analysed into a detail.

Socio-cultural context

Cultural life in the centre of Prague almost stopped for several months during and after the flood. There were many theatres flooded e.g.: National Theatre, Archa, Na Zábřehu, Music Theatre Karlín, Theatre in Dlouhá. National library was closed during and after the floods from 12.8. - 8. 9. 2002. In Klementinum buildings water reached heights up to 350 cm. About 140 000 inflected volumes (not only from national library, but also from other flooded libraries and depositories) were with the help of army transported to cold stores. The archives of the National Technical Museum (NTM), containing architectural plans and models, were severely affected. Many photographic documents in the Institute of Archaeology of the Academy of Sciences of the Czech Republic were also flooded. The affected area in Prague Troja is a mix of residential



Fig. 1 Flooded garden of Troja Château. © Archives of the Troja Municipal District

functions and important cultural functions (Baroque Château and garden, ZOO, Botanical garden, Stromovka park). Some parts of Troja Château gardens were closed after the flood for several years. The floods in Troja also severely damaged Prague ZOO, where many animals died and some escaped. More than 100 of private houses were evacuated and heavily damaged. Some structures of a great historic value were lost when the owners quickly demolished them without permission. These were buildings that were not protected or listed monuments. An example is a house with a preserved timbered wooden wall, which was covered by a brick partition until the flood and only its collapse revealed one of the oldest structures in the area (Fig. 2). Similarly, several buildings in the old ancient druse of the "Fisherman's" houses were lost, which were extremely vulnerable to flooding due to long-term neglected maintenance and had to be demolished. The lost houses were totally immersed in water during the flood. The evicted inhabitants were temporarily accommodated in the premises of the Troja schools or found refuge in the families of neighbours who had been spared the flood destruction. Fortunately, the worst period of the flood occurred during the summer school holidays and was accompanied by good weather. The flooded area had to be protected against looting, which required the deployment of police boats, as the flooded houses became easily accessible by water. The access roads to the affected area were guarded by patrols of military reinforcements, supplemented by local residents with the necessary knowledge of the people and the environment. An invaluable help was provided by child sitters, trained from summer scout camps, who enthusiastically took turns in Home Guard patrols. At the moment of the occurrence of the flood danger, the local government established a Flood Committee and coordinated the preparation of protective measures. The Flood Committee continued its work throughout the duration of the flood and during the removal of debris by providing the necessary materials, protective work equipment to the affected residents and volunteers.



Fig. 2 A timbered wall exposed by the collapse of a brick lining wall. © M. Drdáký

Methods of Reconstruction

After the water receded, all the flooded buildings were inspected by a structural engineer and only after his written statement that the buildings were safe their owners could return to the buildings and start cleaning and repairing the damage. In Prague-Troja, structures in several buildings partially collapsed. Most of them were stone or mixed masonry bonded with clay mortar and wooden structures heavily damaged by biological pests. The buildings were privately owned, and their owners mostly asked for demolition and new construction of similar houses on the same building plot. The small buildings that were swept away by the high water were not rebuilt. The houses that survived the flood without critical structural failures were subsequently repaired with the help of expert advice. Here, cooperation with research institutes and universities proved to be successful, as the huge number of affected houses required assistance from knowledgeable volunteers with the necessary professional certification. The expert assistance was coordinated by the local government's Flood Committee. The local government also lent out desiccant devices free of charge. A different situation occurred in the Karlín district of Prague, where one house collapsed and several others were seriously damaged. These were buildings from the 19th century, often adapted on the ground floor for new large shops with extensive interventions in the load-bearing structures. They consisted mainly in the weakening of the brick masonry pillars, which lost up to 50% of their bearing capacity when soaked with water compared to the dry state. There were also many unused, or temporary used for other functions, industrial factories in this part of the city, in the restoration of which there was neither political nor economic interest. In the Karlín district, the flood opened up a huge opportunity for new development, which continues for more than twenty years after the flood. Unfortunately, it is more focused on building office construction than buildings for

housing, services for citizens or clean production. Several older industrial buildings within the area have been refurbished for new uses. The area is very well served by public transport, including the underground railway. The newly rebuilt district needed to be protected against future floods, which was solved by a comprehensive design and construction of flood protection measures, which also protected the historical centre of Prague. Flood protection measures were gradually extended to the outskirts of the city. Prague Troja thus also gained a barrier against high water protecting a large part of the residential area. The barrier consists of a permanent and removable wall. Due to the fact that during a critical flood the water reaches a height of about 8 metres, the protective embankment with anchor pillars of the prefabricated wall significantly changes the character of the coastal part of the Vltava River in the place where the stream has retained its natural rapids (**Fig. 3**). Fortunately, the protective wall, which is built further from the river bank, is connected to the enclosure wall of the Troja Château garden, and the visual impact is thus mitigated. The disruption of the historical context of the river and the adjacent settlement is the price for the effective and very successful protection of the residential part of Troja, as shown by another major flood in 2013 (**Fig. 4**). The zoo and the adjoining part of Podhoří with very scattered buildings remained unprotected. A substantial part of the rescue work was the restoration of wall paintings and a large number of books, drawings and other paper documents. The murals and historical surfaces were polluted with heavily contaminated water with various chemicals, e.g. ammonia sulphides, CO₂, H₂SO₄, Ca(OH)₂, Na₂SO₃, chlorinated hydrocarbons (Spolana, 2003). A special workplace was set up at the NTM for the restoration of frozen paper, especially documents from the architecture archive, which managed to save all the archival materials.



Fig. 3 A view of the construction of the rampart with pillars for the temporary wall and the connection to the Troja Château garden. © T. Drdáký



Fig. 4 Comparison of the extent of flooding of the residential area before and after the construction of the flood protective embankment (floods in 2002 and 2013). © Archives of the Troja Municipal District.

Population involvement

The cooperation of the inhabitants began during the preparations for the arrival of high water by building temporary barriers made of sandbags and evacuating objects from water-endangered areas. In the end, this activity was useless due to erroneous information from the Prague City Council about the underestimated intensity of the flood. Faulty information about the speed of the onset of the flood wave also led to the premature expulsion of residents from their homes, which also led to higher damage to their property. Cooperation during the flood focused mainly on neighbourly assistance to people displaced from their homes, assistance to the local government with ensuring communication with residents or with the distribution of water, food and work equipment. Last but not least, it was also the above-mentioned guarding of the red zone by volunteers, including youth. After the flood, residents tried to clean up their buildings, yards and gardens as soon as the structural engineer allowed them to enter the property. They behaved in a disciplined manner and took advantage of consultations mediated by the Flood Committee on the correct procedures for rescuing movable objects or pumping water from underground spaces. Nevertheless, the some family heritage was lost, as most of the inhabitants took the flood as a stroke of fate and said goodbye to the mud polluted and water-soaked or even damaged things without much regret. They helped to clean public facilities, pavements and streets. The crisis event became an important initiator of social cohesion in an area where the spirit of collective life and belonging slowly began to disappear. It also attracted many volunteers from friends of the inhabitants, but also a number of people from distant countries. The population's interest in dealing with future protection of the territory has strengthened, which was reflected during the planning of flood protection measures. Public participation in meetings to raise awareness on remedial and preventive measures has increased. Using the knowledge from the floods, a manual for owners and managers of cultural heritage was developed, which is a guide to vulnerability self-assessment, critical identification and resilience measures focused in emergency and disaster situations (Drdácký et al., 2020). Residents regularly attend training on its use. They also participate in training activities for emergency and rescue situations organized by the local Troja government. In addition to the manual, the residents were instructed on the need to keep the property in good condition and provided with a draft form for scheduling regular inspections and maintenance of the building (Drdácký et al., 2022).

Conclusions (lesson learnt)

The catastrophic floods of recent times have brought a huge amount of knowledge and lessons about the vulnerability and resilience of immovable and movable cultural heritage. This made it possible to categorize the types of flood-generated loads and to better design measures that successfully resist such loads and actions (Drdácký 2010). The findings also help to identify critical points of buildings that increase the risk of damage or physical loss. Analyses have shown that the vulnerability is significantly increased by neglected maintenance and the dilapidated state of the building. Therefore, it is necessary to carry out regular inspections of the condition of structures and immediately remove any deficiencies found, which, if neglected, may develop into more serious or even critical defects and failures. There is useful and recommended to prepare both inspection and maintenance plans. In the field of risk management, the quality of information about imminent danger is vital, as well as assistance during the event and ensuring the transmission of this information to the population. The preparedness of the population for a crisis situation through regular training and practical exercises in cooperation with other components of the integrated rescue system should not be underestimated. It also includes training in the evacuation of mobile items to prepared storage areas with a suitable indoor climate. In the case of floods, this also includes refrigerated warehouses for paper documents and books. During the floods, there is a massive loss of family cultural heritage - documents of a personal nature, many of which are of general historical importance. Losses are largely due to ignorance of the possibility of rescuing mobile objects soaked in water or soiled with mud. Therefore, it is necessary to devote time to education about the possibilities of rescuing paper documents, photographs or documents on other media.

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TORNADO HIT IN SOUTH MORAVIAN REGION IN 2021

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Abstract

Tornadoes are rare in the Czech Republic. Buildings here are not prepared for tornadoe strike by design. Damage can therefore be higher and restoration more difficult. One of the largest tornadoes in the history of the Czech Republic swept across the South Moravia region at 300 kph in the evening of 24 June 2021. Critically affected were 7 villages in the area and there were extensive damage to municipal and private property, six deaths and number of injuries. Through a combination of financial support, volunteer work and community initiatives, the affected areas have gradually been rebuilt and made more resilient to future disasters. Some actions were targeted for immediate help, some for longer-term assistance. Moravská Nová Ves was one of the most damaged municipalities and on its example the impact of the devastating tornado and subsequent recovery is demonstrated, namely on examples of the church of St. Jacob, the town hall, the elementary school, the kindergarten, House No. 117, The Doctor’s House and the Sokol Hall.

Introduction – Tornado hit in South Moravia

Tornadoes are not a common occurrence in the Czech Republic, on the contrary, they are very rare. In contrast to countries that deal with tornadoes, the civil engineering field here does not work with the possibility of a tornado strike and buildings are not designed to be prepared for it. Damage can therefore be higher and restoration more difficult. Historical records show approximately 90 tornadoes or damages caused by excessively strong winds. It is likely that in most cases these were smaller tornadoes (mostly F0-F2 Fujita scale), as the reported loss of life can be estimated to be within two dozen for the entire period and damage was minimal in many incidents. (Brázdil et al., 2020)(‘Tornáda v ČR’, n.d.)(‘Seznam tornád v Česku’, n.d.).

One of the most devastating tornadoes in history was the tornado mentioned in the Chronicle of Cosmas in 1119 (translated from original transcription from (Kosmas, 2012)) (Krška & Šamaj, 2001). *“On Wednesday, July 30th, when the day was drawing to an end, a violent wind, even Satan himself in the form of a whirlwind, suddenly struck the princely palace at Vyšehrad Castle from the south, and overturned the old and therefore very strong wall from its foundations, and so - an even stranger phenomenon - where, both sides, front and back, remained intact and unshaken, the centre of the palace was uprooted to the ground, and faster than a man could break an ear, a gust of wind broke the upper and lower beams and the house itself to pieces and scattered them. So violent was this tempest that wherever it raged, in this country it uprooted forests, woodlots, and everything in its path with its violence.”*

A similarly destructive tornado swept across the South Moravia region at 300 kph in the evening of 24 June 2021. It was the largest tornado on Czech territory in modern history and reached the fourth of five points on the extended Fujita scale (EF4).

The tornado's impact zone was 700 m wide and 26 km long. Critically affected were 7 villages in the area of Breclav and Hodonín, namely Hrušky, Moravská Nová Ves, Lužice, Mikulčice, Týnec, Tvrdonice and parts of Hodonín Bažantnice and Pánov. Six deaths and more than 200 injuries, hundreds of damaged houses and more than 1,000 damaged roofs (according to estimates, about 1,600) were caused by the tornado. Around 200 buildings had their structural integrity damaged and had to be demolished. There were 14 county buildings damaged and about a hundred municipal buildings (houses, chapels, playgrounds, etc.). In addition to the destruction of houses, schools, medical facilities, businesses, etc., infrastructure was affected, agricultural areas were damaged, and production of facilities were disrupted. Farmers suffered heavy losses, especially in vineyard areas, which are vital in the region. It is also necessary to mention the destruction of trees, shrubs, woodland and other vegetation, which disrupted the ecosystem. Animals in the forests have lost their natural habitat and some biodiversity has been irreversibly damaged.

The affected villages were without gas and electricity supply for several days. The damage was approximately estimated at CZK 800 million to the property of the South Moravian Region, over CZK 700 million to the municipal property. The total damage is estimated at up to CZK 15 billion (since in many cases private

subjects are involved, exact figures are not available). Thousands of claims have been registered by insurance companies, resulting in billions of CZK in insurance payouts. Unfortunately, the financial support had to include not only direct damage caused by the tornado but also secondary damage caused by heavy machinery during debris removal. (BBC News, 2021)(čt24, 2021)(ČTK, 2022)(Lébllová & Žohová, 2022)(‘Letecké záběry: Moravská Nová Ves dva a půl měsíce po tornádu a těsně po něm’, 2021)(ČTK, 2021a)

In addition to the material damage caused by the tornado, the profound psychological impact on the residents – not only from the moment of the tornado, but also from the subsequent losses and uncertainty about their future - must also be mentioned. Many families were left homeless, putting enormous pressure on their psychological stability. Crisis interventions and long-term psychological support were and continue to be needed. At the same time, there has been an extraordinary wave of solidarity. Many volunteers from all over the Czech Republic, and even from abroad, came to help in the rescue and recovery work. Collections and humanitarian aid brought in substantial funds, which were used to support those affected.

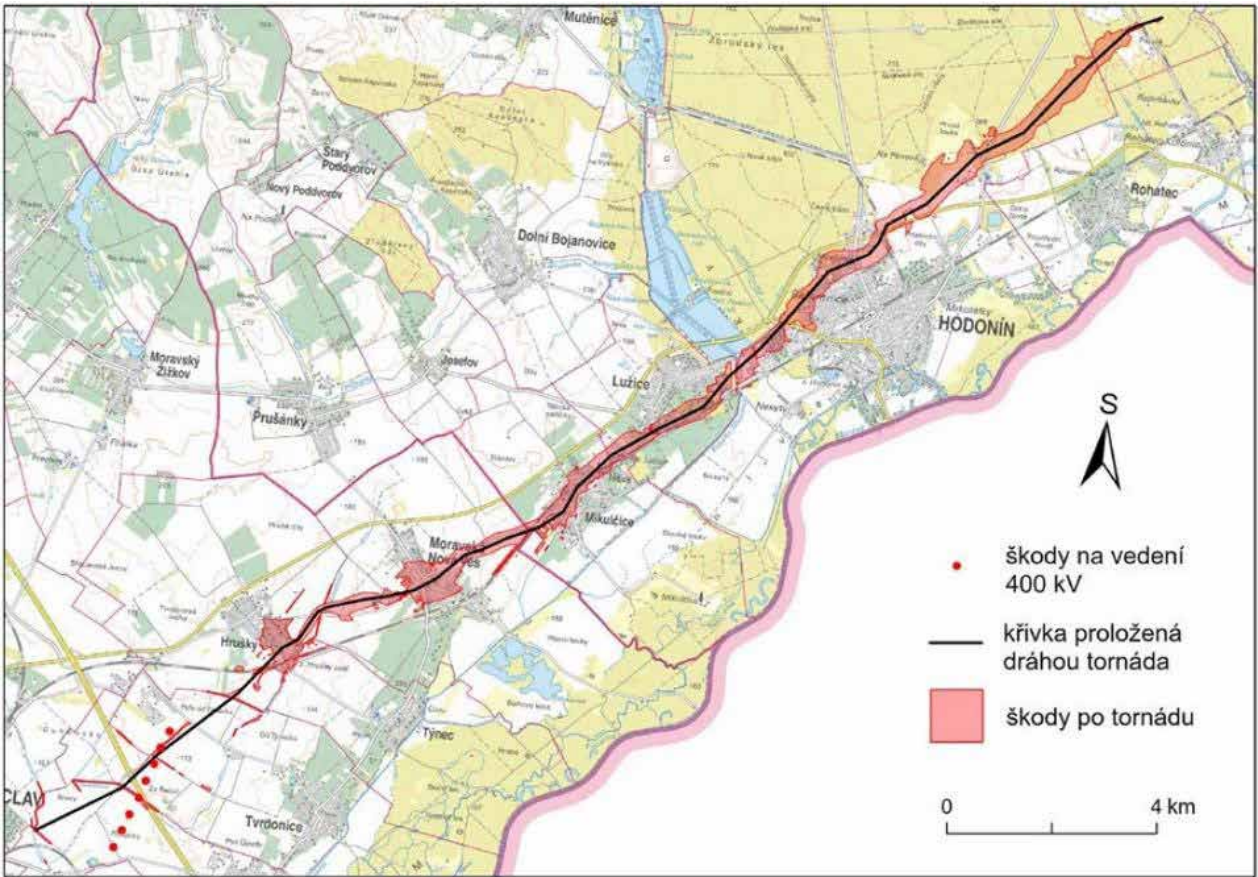


Fig. 1 Route of the tornado's progress. Source: Miloslav Staněk based on data from: ČHMÚ, SHMÚ, ESSL, AMS, PŘF UK, Meteopress, VUT, Amper Meteo, E.ON, map source: ZM 100, ČUZK

Introduction – Tornado hit in South Moravia

Recovery from the tornado in South Moravia represents a complex process that required coordination between local authorities, communities and humanitarian organisations. Through a combination of financial support, volunteer work and community initiatives, the affected areas have gradually been rebuilt and made more resilient to future disasters.

Following the events, a major recovery effort was launched in the affected areas, which not only focused on physical repairs but also included financial and community support. The state released funds to assist households and businesses affected by the tornado. People were able to receive support from various government funds, such as for roof and house repairs. A number of private subjects offered some form of assistance to those affected by the tornado. Some actions were targeted for immediate help, some for longer-term assistance. Immediate assistance was offered mainly by the Diocesan Charity of Brno and People in

Need, as well as other subjects, both for-profit and non-profit, which organised financial collections or offered direct financial contribution. The non-profit organisation People in Need, for example, set up the SOS Morava fundraiser, immediately after the incident sent CZK 5 million to the affected municipalities. It sent CZK 5 million to the affected municipalities for the rapid restoration of the damage and started helping with volunteers in the field to clean up the damage. Diocesan Charity Brno paid out CZK 313 million to affected households. It deposited the rest of the money in a fund for future emergencies. In total, around CZK 1 billion was raised from all the collections made, which were provided both directly to the affected people and to businesses or municipalities for the recovery of public property and infrastructure. (Člověk v tísni, 2023) (Člověk v tísni, 2024)

Volunteers played a vital role in the initial phases of the recovery, helping with debris removal and repairs. In subsequent phases, assistance focused on specific needs such as supplying building materials, tools and other necessary items. Good coordination of volunteer assistance to make it as efficient and safe as possible also played an important role.

One form of longer-term assistance is the Obnova21 initiative, which was founded by several architectural studios (edit architects, desk architects, Marco Maio Architects and YUAR architects). The aim of the initiative is to bring architecture to where it is currently needed. Under the auspices of the Czech Chamber of Architects and the Czech Chamber of Chartered Engineers and Technicians in Construction, the initiative came up with the project House for Slovácko - a family house designed to be placed in the gaps left by destroyed buildings. Its layout and appearance is inspired by the original buildings, so that its construction is a sensitive intervention in an area with a rural character. The project is available free of charge. Lukáš Janáč, one of the initiators of Obnova21, describes the project by saying (translated from czech original (Obnova21, 2021)): *"Our aim is to create a project documentation of a family house with contemporary layout, materials and technologies and to offer this project to the builders in a pro bono form, i.e. free of charge for their final modifications. Not only can this save significant time and costs, but it will also help preserve the historical legacy"*.

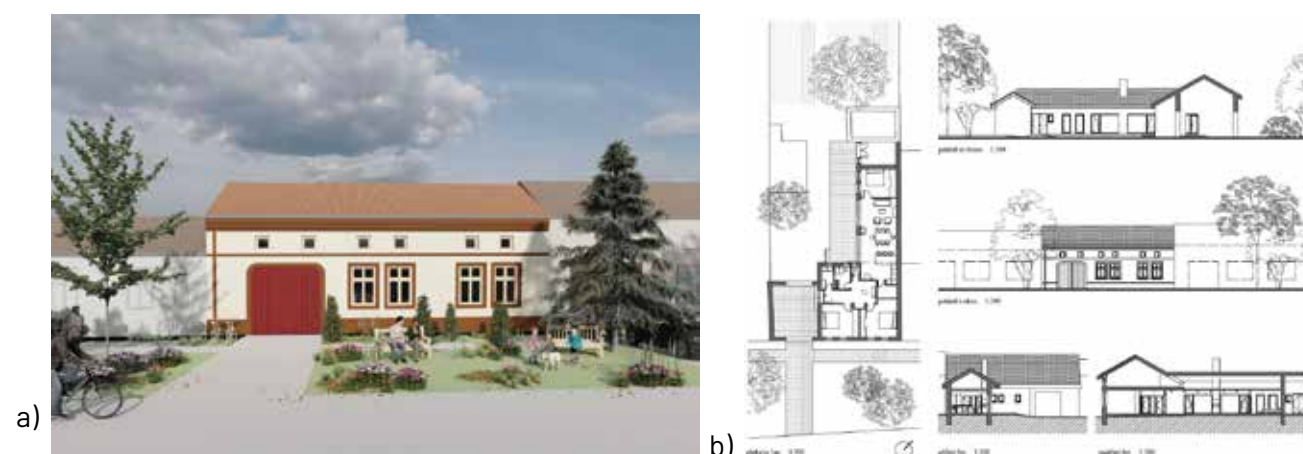


Fig. 2 Design of the House for Slovácko: visualization (a), documentation (b). Source: <https://www.archiweb.cz/n/domaci/typovy-dum-pro-obce-na-slovacku-postizene-tornadem>

In addition to those mentioned above, a number of architects and civil engineers have offered help as well, usually by providing free design work for those affected. The Czech Chamber of Chartered Engineers and Technicians in Construction organised an information day for people dealing with renovation issues, during which free professional advice was provided. (Báčová & Kohoutová, 2021)

The students of Architecture and Civil Engineering at Faculty of Civil Engineering of the Czech Technical University in Prague, under the supervision of teachers Adam Bohatý and Marco Maio, also made an effort to help in the form of a year-long thesis on the revitalization of a multi-purpose municipal house and the adjacent public space in the village of Moravská Nová Ves. The students' proposals were presented to the municipal administration and the public.

Moravská Nová Ves was one of the most damaged municipalities and on its example the impact of the devastating tornado and subsequent recovery is demonstrated.

Impact of Tornado hit on city of Moravská Nová Ves

Coincidentally, a few weeks before the disaster, Moravská Nová Ves had panoramic images of the village taken from a bird's eye view. This allows a relatively good comparison of the situation before and after the tornado. Interactive imagery is available at virtualtravel.cz

The village is one of the hardest hit, with a number of buildings damaged. In addition to the houses, there were, for example, the church of St. James or the hundred-year-old pub (opened in 1922) and especially the objects of the municipal property: the town hall, the kindergarten and primary school, the funeral hall and grave sites, public spaces and many others. The library building was completely destroyed and demolished on the orders of the structural engineer. The damage to municipal property is estimated at around CZK 160 million. Some of the damage was not caused by the direct impact of the tornado, but by subsequent events, for example, before the damaged roof of the primary school could be repaired rain began to fall inside, causing damage to the ceilings. (ČTK, 2023)(Svoboda, 2021)

In the words of Marek Košut, the former village mayor, (translated from czech original (ČTK, 2021b)) "The tornado's strike changed the face of the village forever. The demolished houses will be rebuilt, the damaged ones will be repaired, the mayor believes. *"But it will take several decades to regrow the trees that have completely disappeared in much of the village"*



Fig. 3 Comparison before (a) and after (b) the tornado, Moravská Nová Ves. Source: virtualtravel.cz

Renovation of devastated buildings in Moravská Nová Ves

Moravská Nová Ves received financial support from the state, from the above-mentioned collections and from a collection organized by the municipality itself. A number of subjects, both public and private, provided material assistance, mostly in the form of lumber and wood-based construction materials and bagged materials (cement, glue, etc.).

A large part of the reconstruction focused on the recovery of the infrastructure - repairs to power lines, water and sewage networks and transport infrastructure. Rehabilitation of public school buildings and health facilities was another priority to ensure that basic services could be provided. Work was also initiated to restore agricultural production, particularly vineyards.

Most of the private buildings (family houses, businesses, etc.) are being continuously repaired, especially damaged roofs. Owners are rebuilding the demolished buildings, in some cases abandoning them. Municipal property is gradually being restored, either by renovation to its original state or by more extensive revitalisation to improve its original condition. Priority has been given to repairing infrastructure, school facilities and doctors' practices. Some buildings will not be restored to their original location, such as the library and the former fire station. The devastation of the public spaces also led to preparations for a more extensive revitalisation of the village centre.

Thanks to the cooperation of the local community, construction and design companies, the total renovation of the Church of St. James the Elder in Moravská Nová Ves became a symbol of solidarity and community support in the region. A tornado completely destroyed the roof of the church, built in 1773 on the site of the original Gothic church. The gables had to be rebuilt, the tower with crosses, the bell shutters and the fallen cornices had to be rebuilt, but fortunately the statics of the vaults were not damaged. The local community and a number of companies and organisations were involved in the renovation. After building a temporary roof, glazing the windows and repairing the electrical wiring and distribution, a complete restoration project was prepared. The preparation of the project was complicated, for example, by the lack of documentation, it was necessary to find photographs from which it would be possible to map the individual elements of the gable and roof.

The total cost of the church restoration amounted to almost CZK 24 million, repairs to the area in front of the church and its surroundings another CZK 2.5 million. Most of the costs were covered by donations from the faithful, companies, organisations (e.g. Brno Charity or Hungary Help) and insurance, the Olomouc Archbishopric offered free wood for the new roof and the Liechtensteins contributed to the restoration of the stained glass windows. State did not contribute a single crown because the church was not included in any category for support. (Konvička, 2023)('Tornádo zpusťošilo městys během tří minut. Jak farníci opravili zničený kostel?', 2024) ('Rekonstrukce farního kostela sv. Jakuba Staršího v Moravské Nové Vsi', n.d.)

In summary, it can be stated that the roof and roof trusses of all buildings were damaged. Most buildings suffered secondary damage as a result of the subsequent leakage, such as damage to internal plasterwork or damage to ceilings, which eventually had to be repaired or demolished and replaced with new construction (examples include the primary school or the Sokol Hall). In most of these buildings, it was also necessary to replace window panes that had been damaged by the tornado. In the case of the elementary school, the funeral hall, the town hall, the House of Doctors and others, the need for repairs was seen as an opportunity for major reconstruction or a change of use of the building.

Below are selected municipal buildings and a brief description of the state of their renovation, the information is relative to the time of writing this article. The description is based on sources ('Informace o opravách obecního majetku po tornádu - časový přehled 8/2021 - 2/2022', 2022)('Informace o opravách obecního majetku - Září 2022', 2022)('Informace o opravách obecního majetku - Září 2022', 2022)('Oprava budov a veřejného prostranství po tornádu – prosinec 2022', 2022).



Fig. 4 - A view of a part of the tornado-damaged Moravská Nová Ves with the Church of St. James the Elder in the middle. Source: https://katyd.cirkev.cz/vydani-20210629/z-domova/tornado-nicilo-ale-odkrylo-lidskost_8716?media=desktop

Town Hall

In addition to the common signs of tornado damage (destroyed roof, damage to the roof truss and gable, windows facing the street and façade, damage to the interior), the interior of the building was negatively affected by its use as a base for rescue work. On the positive side was the discovery of original Baroque roof trusses under the ceilings of the attic flats, which otherwise would probably not have been discovered. The Baroque roof truss was restored using traditional hand-crafting techniques and the space now serves as a new ceremonial room..



Fig. 5 - Town Hall: the Town Hall building after the intervention (a), the reconstruction of the Baroque roof (b), the renovated Town Hall building (c). Source: <https://www.mnves.cz/projekty/obnova-budov-po-tornadu-obnova-radnice/>



Fig. 6 - Kindergarten: damage after the hit (a), destroyed playground (b), building after reconstruction (c). Source: <https://www.mnves.cz/projekty/opravy-budov-po-tornadu-materska-skola/>

The tornado completely destroyed the roof and insulation. After the tornado, a new roof, window replacements, and interior repairs were made, including the originally planned addition. New play features and a gazebo were installed in the backyard. Repairs were completed in 2022.

Elementary school



Fig. 7 Elementary school: damage after the hit (a), repaired truss (b), completed extension (c). Source: <https://www.mnves.cz/projekty/oprava-budov-po-tornadu-zakladni-skola-2-stupne-mestanka/>

The roof, including the roof truss, was completely destroyed in the school buildings, resulting in damage to the ceilings due to subsequent leakage. The structural engineer instructed to remove the ceilings on the 2nd floor, the remaining ceilings had to be renovated as a priority and partially replaced with new reinforced concrete ceilings. This situation was used to unify the room heights. The general repair was completed in 2022. The façade was restored to its original form and the interior furnishings were revitalized to meet contemporary requirements during the repairs. The building has been redesigned in terms of accessibility. The supplier donated part of the building materials free of charge. The athletic oval and playground were also renovated after the debris was removed from the school yard.

Sokol Hall



Fig. 8 Sokol hall: damage after the hit (a), reconstruction of the roof truss (b), visualization of the reconstruction design (c). Source: <https://www.mnves.cz/projekty/rekonstrukce-sokolovny/>

The roof and roof trusses, the facade and window panes were completely destroyed. The subsequent leakage also damaged the interiors. Part of the ceiling was torn off and the structural engineer had to order demolition. After the necessary repairs to the roof to prevent further degradation, the building served as a temporary base for rescue work and material storage. The building required a complete renovation, which was linked to the planned repair of the technical facilities, stage and boiler room. Eventually, the project for the renovation of the building also included areas that were not directly damaged by the tornado but required restoration (e.g. the pub premises).

House No. 117



Fig. 9 House No. 117: damage after the hit (a,b), repaired building (c). Source: <https://www.mnves.cz/projekty/oprava-budov-po-tornadu-oprava-budovy-c-p-117/>

The necessary renovation after the tornado (the roof was destroyed, nearly all the windows were destroyed, the interior was also damaged due to the subsequent rainwater leakage) was used as an opportunity to partially change the use of the ground floor and adapt the attic to usable spaces. The original roof truss was restored and partially supplemented with steel elements and a new reinforcing concrete wreath was made, which was missing in the original structure. New acoustic ceilings were added to the ceiling structure to allow the space to be used for an art school. The premises are also designed to be used temporarily for primary school teaching until the renovation of the school building is completed.

Doctors house



Fig. 10 Doctors' House: damage after the hit (a,b), building after almost completed reconstruction (c). Source: <https://www.mnves.cz/projekty/projekt-1/>

The need to renovate the building in the courtyard of the municipality areal was also used for more extensive changes of use, namely the building was adapted to accommodate new doctors' practices and the waiting room was extended. A new roof was constructed, and the renovation was also used to insulate the building. The renovation also included floors, electrical installations, new water and sewage systems.

Conclusions

Tornadoes are undoubtedly one of the symbols of climate change and represent extreme weather events that can disrupt entire regions that were previously unaccustomed to such natural disasters. The damage caused by a natural disaster is more extensive in places where this type of disaster is neither common nor expected and buildings are not structurally prepared for it. The Czech Republic is one of these places – tornadoes are not common on its territory and buildings are not designed for a tornado hit.

For the most part, the damage caused is due to the impact of wind-drifted objects rather than the tornado itself. In most cases, damage is more extensive for wooden structures than for masonry structures with massive vertical walls. Roofing and truss structures are therefore usually the most damaged.

In the period between the immediate damage to roofs and their emergency repair (temporal covering), leakage may occur, resulting in secondary damage to the interior, as well as to internal load-bearing structures, such as ceilings, which may need to be demolished and replaced. This secondary damage can in many cases lead to the need to demolish and replace structures or entire buildings.

The consequences of a tornado (or other disaster) can therefore be more extensive than is apparent at first sight. Primary damage can lead to secondary damage in the parts not directly affected by the disaster, as shown in the examples above.

The devastation of the urban structure by a natural disaster can thus paradoxically be a good catalyst for change and opportunity. Buildings that would normally undergo only necessary maintenance or deteriorate can become the subject of more comprehensive revitalisation, retrofitting and change of use.

In other cases, deterioration and necessary repair can lead to positive findings from a heritage conservation point of view, such as the uncovering of older original layers. This can lead to their restoration and the preservation of preserved values that would otherwise remain hidden.

In the future, it is likely that similar phenomena may occur more frequently due to climate change. In addition to greater respect for our planet and its ecosystem, it will also be necessary to adapt to climate change, which is probably already irreversible. Preventive measures should include, for example, adjusting building standards and designing buildings to withstand the effects of natural disasters that have not previously occurred in a particular location.

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METHODS AND TOOLS

Section

2

Theoretical Framework

STRUCTURED APPROACH TO HOLISTIC RECONSTRUCTION

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Entropy and new opportunities

Sustaining or reviving a community and rebuilding sites after being struck by a disastrous natural event requires concentrated energy and targeted efforts. Usually, the driving force is a natural reaction of the affected community applying a culturally rooted “urge” of resisting the entropy. This inner force of the community is dependent on various factors, however, a tendency towards a swift response of well-organized communities in protecting or re-erecting main cultural monuments or symbols of local identity has been observed. In the case of Accumoli, the city tower has been secured with additional structure after the quake in 2016 to protect the symbol of local identity from possible aftershakes, enabling it to withstand the second earthquake in early 2017 (**Fig.1**). This has to do with motivation, hope, and demonstration of agility. Such an approach can be described as organic. On the one hand, in this way the community can benefit from experiencing increased motivation, but too quick action can induce premature decisions, suboptimal implementation of structural, technological, or urban improvements, and to some extent even cause damage. Although a structured approach appears to be of longer duration, it provides better grounds for a holistic reconstruction process and enables participative enhancement of affected sites and, through the process, also restructuring and fostering communities.

However, tragic and disruptive destruction induced by natural disasters can often provide a possibility of improving urban structure and infrastructure, as well as being an impulse for revival of the invisible social and economic networks of the affected sites. As one of numerous cases, the Abruzzo region exemplifies a



Fig. 1 The tower of Accumoli – a symbol of its identity – wrapped in reinforcing structure which helped it to survive the second earthquake in 2017. (Author)

paradoxical situation of an area of inner Italy that already struggled with demographic, economic, and infrastructural decline when struck by a devastating earthquake in 2009. Therefore, the disaster amplified the challenges to overcome. Similarly, in 2016 and 2017 an earthquake repeatedly hit the town of Accumoli in the Lazio region, which at the time had already been affected by rural depopulation (Fig.2).

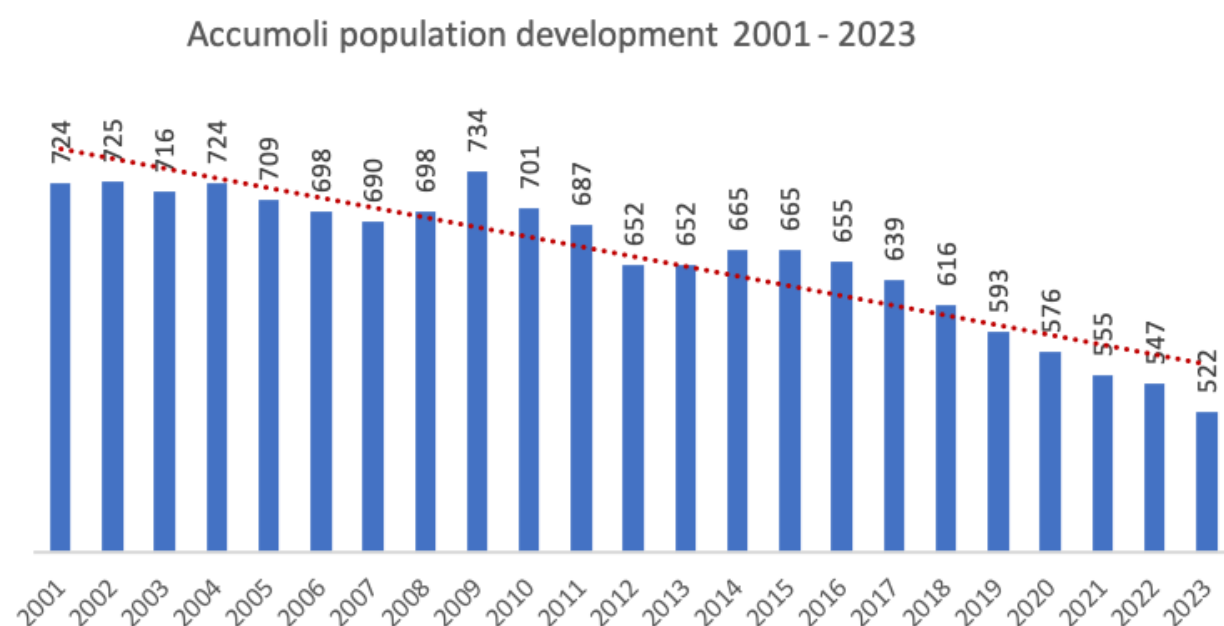


Fig. 2 The estimated resident population of Accumoli shows an already declining trend that accelerates slightly after the earthquake in 2016. (Author based on data sources: 2001-2019 (Istat Statistics, n.d.) and 2020-2023 (Istat Statistics, n.d.)).

Revival of Marginalized and Successively Destroyed

In 2014, the Italian government introduced a National Strategy for Inner Areas (Strategia Nazionale Aree Interne; SNAI) (Agenzia per la Coesione Territoriale, n.d.) was introduced by the Italian government. This policy has been aimed at developing fragile marginalized areas located outside of main centers lacking essential services and facing demographic decline, with the regions of both named examples (L'Aquila and Accumoli) included among them. The territories targeted in SNAI account for 22 % of the Italian population and cover 60 % of the country's surface. (Agenzia per la Coesione Territoriale, n.d.) They are considered the most authentic areas of Italy. To preserve these areas and their communities from disintegrating due to depopulation, action plans were introduced to enhance their natural and cultural resources, promote their assets, and create new employment circuits and new opportunities. (Agenzia per la Coesione Territoriale, n.d.)

Based on the analysis of earthquake occurrence in Italy between 1861 and 2011, there has been a significant earthquake every 4-5 years. (Guidoboni and Valensise 2011) The response and post-disaster reconstruction approach have been varying in terms of social, economic, technical, legislative, and administrative aspects with different levels of involvement and leadership between local, regional, and national authorities. (Di Giovanni 2016)

According to di Giovanni, L'Aquila represents an anomaly in Italian inner areas – the earthquake worsened the preexisting conditions of its marginalization, however, the post-earthquake funding and the reconstruction initiated '(...) offered uncommon resources to shape transformative patterns of development, collaboration and innovation.' (Di Giovanni 2016)

In the case of the Abruzzo region and its capital L'Aquila, in addition to the SNAI, a legislative framework has been implemented defining 'Reconstruction plans' as extraordinary planning instruments to guide the reconstruction process toward its overall objectives: ensuring social and economic recovery; promoting urban redevelopment; facilitating residents to return home. On the one hand, the legislation aims at targeting ambitious short-term and long-term goals targeting specifically social and economic issues rather than mere physical rebuilding of structures. On the other hand, it contradicts transformative purposes by restricting financial support only to the compensation of the damage that occurred, resulting in disconnecting physical reconstruction from the implementation of social and economic aspects. (Di Giovanni 2016)

The innovative approach of clustering small municipalities to homogenous areas aiming for inter-municipal cooperation and synergies reflects the polycentric nature of Italian regions. If managed well, it provides a good base for building synergies in economic, social, administrative, and infrastructure matters. The SNAI and the Abruzzo post-disaster legislation both support this approach; however, the lack of implementation due to absence of clear division of responsibilities has been criticized. (Di Giovanni 2016)

During the 3-year emergency phase in the aftermath of the 2009 earthquake in Abruzzo, national boards played a significant role in the reconstruction process. A gradual shift of responsibilities towards local administration took place, fostering cooperation between central, regional, and local authorities. (Di Giovanni 2016) Given the level of displacement of towns and villages in the peripheries, local management of the reconstruction process appears to be the right choice. On the other hand, the level of individuality and missing clarification of roles in the inter-municipal cooperation seems to be the weak point on the path to reaching goals of the still ongoing reconstruction.

Tourism as a cure?

Tourism is often defined as the economic cornerstone of regional revival (which seems to be applicable to many peripheral parts of Italy) (Dalsgaard 2012), as demonstrated by the SNAI. (Agenzia per la Coesione Territoriale, n.d.) This approach appears to be overrated, mainly if the creation of jobs and infrastructure for this sector is neglected. Moreover, tourism does not make places attractive to locals for living, nor create values per se. The unique identity of regions, cultural values, traditions in harmony with nature along with systems and services that promote and protect these values and at the same time develop caring communities makes living in these regions attractive, creates resilience, and a sustainable connection between people and space.

The locals are the bearers of local/regional wisdom and knowledge passed on over generations. They stand behind cultural values, local heritage, passing on traditions, stories, cultivating the landscape and settlements. The creation of inaccessible areas (red zones) after disasters results in (best case in temporary) detachment of urban structures and inhabitants documented in the film Human Scale as a consequence of the Christchurch earthquake in 2011 (Dalsgaard 2012). Individual memories may begin to fade, but by preserving the community and its collective memory, they can be revoked and stored. After the earthquake, the city of Christchurch, with a population of nearly 400,000 aimed to build back better and in cooperation with Jan Gehl, engaged its inhabitants, resulting in collection of 106,000 ideas and contributing to reconstruction plans for a low-rise, resilient, safe and sustainable city. (Gehld, n.d.)

Returning home

A fundamental question in the reconstruction process is why people should return to affected areas after a disaster. From the perspective of a holistic reconstruction, returning original inhabitants to their homes (or home areas) is crucial for being able to sustain local culture, traditions, identity, collective memory, etc. What might be sufficient motivation for people to rebuild their places and continue to live somewhere where they can face the same terror again? Otherwise, if people do not want to come back, the effort of reconstructing a place makes little sense, and conservation or gradually decaying structures can serve as monuments.

According to a survey conducted among residents affected by Hurricanes Katrina and Rita that hit the eastern coasts of North America in 2005, people act differently in real situations compared to expectations of people based on theoretical scenarios. Evacuees who really lost their homes are willing to return to their settlements significantly more often than unaffected people declare that they would do in a hypothetical case. (Reinhardt 2017a)

Sociological research can offer explanations for the way people deal with disasters. Findings of a survey conducted after the above-mentioned hurricanes suggest that trust (or distrust) toward local public officials based on their performance in emergencies (aid delivering, information provision, etc.) is a great contributing factor. 'Even after incredibly destructive disasters, good experiences with public officials actually strengthen the resolve to live in threatened areas.' (Reinhardt 2017b) Further, the survey identifies a discrepancy between the outlooks perceived by 'bystanders' through the media covering those people's disaster and the directly affected by the complex perception of financial, social, psychological, economical and other aspects of the

situation. This complex network may motivate people to return or prevent them from leaving the place. Finally, although difficult to quantify, the survey confirms that ‘(...) many choose where to live because ‘it just feels like home’. This sense of place compels people around the world to live where they do. The longer a person’s family has lived in a particular area, the more likely that person is to return home after being evacuated. Likewise, the stronger their ties to church communities, neighbours and local economic activities, the more likely that person is to try to go back.’ (Reinhardt 2017b)

Role of community

A strong sense of community is the natural and probably most important backbone of resilience, especially in smaller settlements. The goal of municipal or regional administrations should be to support activities that contribute to the formation and strengthening of communities. In peaceful times, this helps to foster social and economic interconnections and shape development. It creates mutual trust between inhabitants and officials. These relations are essential not only when facing immediate events of natural disasters or man-made catastrophes, they are much more important when dealing with and overcoming destruction on mid-term and long-term scale. In case of disasters, municipalities with less developed sense of community might use the reconstruction process as an impulse for engaging inhabitants through various online and offline tools. Participative planning, capturing collective memory, fostering collaboration, empowering working groups, identification of challenges, and potentials are just some examples of campaigns in which a local community can begin to take shape and gradually increase resilience while redefining the sense of home. Building back better means beside rebuilding and improving former physical structures also redefining underlying services, economic, social, environmental and other layers.

For a successful holistic reconstruction, understanding local/regional values is one of the keys. Not only are perspectives from within a community needed, but also observations from outside are needed to identify uniqueness of local/regional heritage as well as similarities with other situations from which experience and best practice can be beneficial.

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Fig. 3 The architect explaining and transferring local knowledge to international group of experts of the ComPaRe project discussing previous state of Accumoli and possibilities of further development. (Author)

FUNDAMENTAL QUESTIONS AND ANALYSES IN THE RUN-UP TO RECONSTRUCTION.

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Binding and freedom in the reconstruction

In the approach of a reconstruction, fundamental questions always arise that cannot be dealt with using a checklist. Their multidimensionality can be outlined using the history of the Piazza del Popolo in Ascoli Piceno as an example.

Like much of the region, this attractive square has an ancient history, although it is unclear whether it was already a trading centre or forum. In the later Middle Ages, it became the Piazza delle Scaglie, whose name is a reference to the fragments of stone left behind by the stonemasons during the construction of the Franciscan church. In 1509, the decision was made to clean up the area. Money and the approval of Pope Julius II were given in return. [1].

The main idea was to create a new trading centre and at the same time a new meeting place for the citizens. In addition to the paved square, the realisation of this idea was determined by two colonnades, one on the eastern long side and the second on the northern short side.

Above the porticoes, interested and correspondingly wealthy citizens were allowed to build a storey of a predefined height. There were further conditions regarding the choice of materials (brick and travertine) and a unified window shape.

The dimensions of the square follow the theoretical guidelines of Leon Battista Alberti and Antonio Filarete. Both Alberti and Filarete were concerned with the theoretical and practical principles of architecture and referred in their writings to the most respected architectural theorist of antiquity, Vitruvius.

The specifications given by Alberti and Filarete for the design of a square were followed exactly. The effect as a gathering square was very strong and can still be experienced as such today.

How it was achieved in detail can only be inferred incompletely: from contemporary documents, especially from their reference to Alberti and Filarete, and from what is directly perceptible.

What is astonishing about this approach is the fact that it was possible to combine taking old experiences seriously with the pursuit of new, current needs. We are familiar with elements such as novelty combined with continuity and recourse to building techniques and design from various building eras. In the Renaissance, however, both elements stand out clearly: there is much that is new and there is an impressively strong link to history.

The civic communities in central Italy developed a fundamentally new freedom during the Renaissance and institutionalised it with a relatively high degree of stability. With astonishing effect: an unusually large number of obviously talented and at the same time very committed people became visible with their passionate work [2].

It is precisely these very freedom-conscious individuals who are bound to ancient models in their preferred languages, in their verse metres, but also in the basic rules for dimensions in art and architecture. They do not feel restricted in their freedom as a result and, as we can see very clearly from a greater distance, they create many new things within supposedly strict rules.

The question that arises here is: why was there no problem with being bound to old experiences instead of drawing on one's own and realising them as one's own? Why this urge to reach back? An open question.

Finding one's own in the bond and experiencing the bond as great freedom is a rather surprising characteristic of the Renaissance for us (impressive examples of this: Alberti's fake of a Vergil poem, sculptural studies by Michelangelo and others).

[1] These sparse references are repeatedly quoted by the relevant media. We were unable to find any academic work on the history of the square, either on site or during other research. Archive studies would be necessary here.

[2] Cf. Agnes Heller: Renaissance Man. London, Boston, Henley: Routledge and Kegan Paul, 1978..

This is perhaps so surprising because for more than 100 years we have rejected any connection to role models in art and architecture, seeing them as a weakness and lack of originality and considering the absolutely new as a sign of unmistakable individuality to be highly desirable.

When reconstructing damaged works in need of renovation, on the other hand, the exact uncovering and preservation of the existing structure is today the highest and often the only goal. Unavoidable additions must be made using current means and be easily recognisable as such, which in the field of architecture very often leads to the ultimately alien-looking use of steel and glass.

In the case of smaller individual edifices, this basic attitude can be accepted calmly. However, when it comes to larger ensembles that require revitalisation in addition to the desired renovation, the question becomes burning: How much new can/must be incorporated into the restoration so that a place becomes worth living in and gains new attractiveness?

In the case of Accumoli, we are faced with an unusually high degree of destruction. Nevertheless, it would be possible to restore all of the formerly intact buildings. Many of them would no longer be needed in their previous or already unused form. A change of use would have to be considered from the outset. But how exactly should they be restored in this case?

In this context, there are two groups of partially mutually exclusive objectives.

A – First and foremost, we want to have back what existed and was familiar to us until the destruction.

B – We want to fill this place with new life and would therefore like to accommodate the new ways of life, if necessary, with structural compromises.

The group of destinations in the sense of A runs the risk of leading to a museum with low attendance.

Group B, on the other hand, became a potpourri of building forms that made the loss of the former building fabric all the more noticeable.

The example of the Renaissance mentioned above could open our eyes to a third option: One could adhere strictly to the old models in the choice of techniques, materials and building forms and at the same time think of the new, with greater freedom than might be assumed at first glance.

Both scopes, the adherence to traditional techniques, materials and building forms and the struggle for adequate and attractive space programming in an architectural as well as in the cultural sense of the term do entail a lot of specific difficulties. In the following, we take a look at them.

Limits of reconstruction

We see reasons for the many limitations of reconstruction in at least four areas. As a rule, they are particularly evident in larger projects. In our analysis, the situation of Accumoli has a special and exemplary weight.

- Human resources in the executing crafts.
- Availability of materials.
- Legal regulations regarding statistics and their interpretation
- Unclear or contradictory objectives about the result

Aiming for solutions

Looking at the situation in the **A Segment** and its previous history, it can be seen that many crafts have been lost in the rural regions of central Italy for some time. This affects the area of carpentry in an unexpectedly sharp form. For more than 50 years, roof trusses have been built exclusively in the form in which masons construct them with the help of steel-reinforced beams, prefabricated or manufactured on site. In the background to this is a loss of knowledge and confidence in timber connections. Both are influenced by a legal situation that is wrongly interpreted in such a way that wood as a load-bearing material is no longer an option. There are only a few companies that use wood (most of it industrially prepared) in construction. However, the timber joints commonly used, are hardly an option for historical buildings, and the older structural techniques

are now largely unknown. This leads to a considerable lack of human resources for reconstruction and usually means that specialists have to be brought in from far away. This is often not financially viable.

In the **B Segment**, the situation for construction timber is also very difficult. The traditional type of wood for beams is mainly chestnut. It is usually only found in smaller dimensions because several waves of disease have taken their toll on chestnut trees in recent decades. In addition, there is now a lack of small sawmills that can process and supply lengths of over 4 metres directly and on demand.

In the stone material sector, the situation is mixed. Where tuff has a long tradition as a material, a great deal is still possible and the possibilities are also expanding thanks to better cutting techniques in the quarries. Where unhewn or less hewn stone is in demand, there is a reliance on demolition material, which is only available in very limited quantities. Overall, however, the situation with stone is not nearly as difficult as with cellular dolomite quarry stone in Switzerland or Austria. There are still smaller quarries in almost all regions. However, the former diversity of local stone types has been severely curtailed here too. Revitalising old quarries usually remains a pipe dream because official permits - as everywhere in Central Europe - are very difficult to obtain.



Fig. 1 Entrance area of a new stable and barn building in the form often found in the Vinschgau Valley. Wood species: larch and spruce. Plastering as lime plaster with lime putty as a binding agent. The sand comes from the immediate surroundings and has special colour effects indoors; outdoors it produces a surface typical of the area after (slight) weathering. (Photo: Josef Perger)

In **Segment C**, it should be noted that in Italy after the earthquake of Friaul (in 1976) there have been, step by step, stricter regulations for structural engineering following major earthquake events. As a result, the traditional structural connections in construction, both wood and stone, have changed from a load-bearing function to a purely decorative one. Safety is attributed exclusively to steel as a material. The required amount of steel can also be calculated by smaller structural engineering offices. All other materials are subject to a testing requirement that can only be met by very large industrial companies. This has consequences for the development of the crafts, and it has consequences for the final result of restorations. The difficulties mentioned above can only be adequately addressed in the case of public sector clients, and even then, only in the case of important objects, although the problems mentioned for areas A and B also exist here.

We also see serious problems in **Segment D**. They are related to several factors. Fundamental to them is an underestimation of the importance of clear and long-term objectives regarding the utilisation of restored properties. Saving a building stock from decay, especially if it is situated in an important landscape or urban location, appears to be the primary objective with great naturalness. Others very often fall apart from interest and support. However, there are an increasing number of buildings in central Italy that have been restored, mostly as part of European Union projects, but which fall into a new state of decay soon after the work has been completed. This is usually because long-term maintenance has not been clarified and consequently cannot be financed.

The aim should be to find a form of utilisation that guarantees the preservation of the restored buildings, ideally a form of utilisation that is self-sustaining and supports the preservation of the building. This is very

difficult to find in the countryside, and also in the case of remote buildings, and is only successful in the context of larger communities or very attractive tourist locations. But even in successful cases, questions often remain as to whether the new use really serves to strengthen the character of a property. The fact is that finding and institutionalising a permanent and appropriate form of use for a restored building is of the utmost importance and should ideally be established before work begins.



Fig. 2 Extension of a medieval Tosco-Latio building with a 'Stöckel building' (right in the picture). The extension turns the house with 1 room (above the cellar), which was difficult to use, into a house with 3 rooms plus bathroom. Materials: Tuff partly from demolition, partly newly cut and a little travertine. (Photo: Josef Perger)

Conclusion

Conclusion from A-D for Accumoli: all four problem areas are virulent. To make matters worse, given the high degree of destruction, there is no structural bridgehead situation from which to begin reconstruction. This means that there are many open paths, but also few 'handrails' for objectives. The crucial question is: who will want to live in the rebuilt Accumoli and with what kind of lifestyle?

To get an idea for a possible answer to this crucial question, we recommend a very intrinsic study of salient advantages and disadvantages, together with the very specific character of the region.

Accumoli application: solutions through interaction with urban regions

We see 4 areas for possible development, which are obvious for different reasons, but each has its difficulties: agriculture, crafts, teleworking, art and music. [3]

AGRICULTURE

The products of traditional agriculture in the region realise low prices. They usually involve a lot of labour on an inevitably small scale. In the end, at least some of the money has to come from somewhere else.

[3] The following list of interests is based on 40 years lasting observations by the author made in the region of Tosco-Latio.

CRAFTS

The materials available in the region are wood, travertine, minerals and textile fibres. The relatively limited quantities available on the market require craftsmanship for refining and higher revenues. Unfortunately, traditional craftsmanship in Italy is more marginalised or neglected than elsewhere. The reputation of the craftsman is low. Parents don't necessarily want to see their children there. And young people very often see far too few opportunities for personal self-realisation there.

TELEWORKING

Often touted as the saving straw for rural communities. It works under certain circumstances. Rarely, however, detached from personal interaction with customers, clients, and collegial communities. Even when working remotely, you have to be physically reachable, at least at certain intervals. Those who are very difficult to reach in terms of transport are in a much worse position.

ART, MUSIC, CULTURAL EVENTS

The region of Accumoli, like other rural areas of central Italy, had a strong connection to music and also produced a lot of art (especially in the intermediate area of crafts and art). The influence of the early art of the Pikenoi can be felt, similar to that of the Etruscans in Tosco-Latio. Today's art is more at home in the cities and should return to the region. The conditions for this are very difficult.

Solving difficulties

We start from the hypothesis that the difficulties mentioned above could be partially solved and fruitfully overcome with interested support from outside.

Any form of solution contribution must address the crucial question in at least three of the four areas mentioned: What can be credibly promised so that professional migration to urban or much more densely networked regions is no longer so attractive?

We believe that emotional attachment to the region is a manifold and indispensable aspect of any form of movement in favour of the region. This can be observed, both among the local population and initially among outsiders. It can become stronger or weaker, and it can be encouraged.

However, emotional bonds cannot simply be programmed and organised. They can be encouraged, but even encouragement is not easily heard in this context.

It is most likely to succeed when the sponsoring Entità (Italian for private or public institution) is represented by specific individuals and is very well established in the relevant areas, and is anchored in the region. This anchoring can be seen in small, often seemingly insignificant details.

For example, when discussing the value of local materials, a consultant must convey that he/she knows from personal experience what is being discussed. No evidence is needed for this. You take it from his/her references and feel it in the speech.

Take wool, for example: it is usually thrown away because it is not worth packing into sacks. This is a hard, repetitive experience for farmers. What could a consultant do to prove the opposite?

Through purchase, brokerage and reliable information about successful sales in other regions. As a result, the offer to join new networks is also attractive. Networks are rated particularly highly in Italy. However, they only exist or function in comparatively few areas when it comes to belongings of the periphery. And if there is an indication of potentially accessible networks, people immediately and very closely scrutinise whether they actually would work.

Beyond all forms of production with locally available or extractable materials, the emotional connection with the region can also be strengthened by what is simply there and only requires an extensive form of dedication, namely, landscape and nature. Devotion to the non-purposeful parts of nature: could there be a new movement, similar to the Alpine Association or its counterpart, the Friends of Nature?

Both were urban movements that turned towards the periphery and, to a limited extent, opened up new perspectives among the local population. With a subsequent narrowing of perception in mass tourism. Could there be a return to nature without mass tourism? A difficult question that has something in common with

the one that has been discussed to some extent for the Alps: could we imagine skiing on the slopes going completely out of fashion in the Alps and something completely different taking its place?

Does the hope of the periphery as a whole lie in a strong connection to urban centres and their perhaps new view of nature?

The reference to nature has been thematised again and again in European literature, painting, music and in various (sometimes dubious) movements since the Romantic period and has led to waves of interest in landscapes. This was followed by more or less mass movements.

The now almost forgotten summer retreats of Viennese citizens and their loyalty to a place or a landscape over decades were by no means mass movements, but they were culturally, socially and economically significant. These city dwellers brought interest, often help, an opening of perspectives and, of course, money to the places of their choice. Would something like this be conceivable from Rome for Abruzzo and in particular for the region around Accumoli? Could musical and other regular summer events provide additional support? The Scuola di Ricostruzione has taken its first successful steps in the field of music.

Conclusion: Involving the interested local population on the one side and on the other side, people and institutions (coming from urban or other rural regions) who would be willing to contribute to the future development of the Accumoli region, both together, could be a very promising mix of endeavouring.

EMPATHY AND SENSIBILITY IN CONCEPT DEVELOPMENTS FOR DISASTER-AFFECTED AND DESTROYED ARCHITECTURE AND URBAN STRUCTURES

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Introduction: Understanding the Scope of Loss

People affected by natural or man-made disasters face profound and multidimensional losses, ranging from physical destruction of property and possible deterioration of health as a result of injuries to emotional and psychological problems resulting from the loss of loved ones and the breakdown of the community fabric. Therefore, a catastrophic event disrupts the continuity of life, leaving affected individuals to face unprecedented challenges, often with limited resources (both economic and mental). Although financial support can replace some of the material losses and is usually straightforward, restoring emotional and social well-being requires a deeper, more empathetic approach. Recognizing social needs and understanding the inner world of emotions of individuals and communities takes time and effort, but it is also key to promoting holistic healing and sustainable community recovery.

According to the Sendai Framework for Disaster Risk Reduction, it has been confirmed that community preparedness for a disaster poses a critical factor to recover and 'Build Back Better'. (United Nations, Department of Economic and Social Affairs, n.d.) Disaster-prone communities (but not only them) should approach the rehabilitation and reconstruction process by integrating disaster risk reduction principles into the development of plans, increasing their resiliency. However, in most cases of severe disasters, due to the extent of destruction, local communities are depending on help from outside in the most urgent matters such as rescuing lives, securing buildings, and infrastructure. In these first moments, often red zones - inaccessible areas - are declared separating the community from their sites, owners from their properties. During this stage, when community members are excluded, a lot of additional damage is caused and values and elements of local identity get lost due to insensitive implementation of securing measures as and removal of rubble. In this way, due to the lack of empathy, the human rights of affected communities are often broken.

Framework Definition

Empathy, as defined by the Merriam-Webster Dictionary, the capacity of understanding, being aware of, being sensitive to the feelings, thoughts, and experience of another's emotions ('Empathy', n.d.) forms the foundation for compassionate responses in disaster scenarios. Sensibility complements empathy by fostering awareness of emotional and social contexts. Together, they provide a framework for integrating emotional intelligence into disaster management, ensuring that recovery processes address not only physical needs, but also the dignity and psychological well-being of affected individuals. To be able to overcome disasters, learn from them and transform towards resilience, it is necessary to make use of 'individual and collective capacities, emotions (such as empathy), attitudes (such as social responsibility), actions, and behaviours (such as mutual aid), which are conducive to social learning and transformation towards sustainability, must be harnessed and strengthened'. (Angelo Jonas Imperiale and Vanclay 2021)

In Disaster Risk Reduction Terminology, the United Nations Office for Disaster Risk Reduction (UNDRR) distinguishes between the term reconstruction and recovery. Reconstruction is understood as: 'The medium- and long-term rebuilding and sustainable restoration of resilient critical infrastructures, services, housing, facilities and livelihoods required for the full functioning of a community or a society affected by a disaster, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk.' ('Reconstruction', n.d.) The definition of the term recovery shifts the focus stronger towards the systems and relationships interconnecting a community (Fig. 1): 'The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk.' ('Recovery', n.d.) The interdependency in different strata of the post-disaster reconstruction process is obvious in theory. However, in many real-life cases, a lack of attention to the implementation of social recovery can be observed. (Nakagawa and Shaw 2004), (Di Giovanni 2016)

International documents emphasize that 'Post-disaster interventions must avoid negative environmental and social impacts, as well as damage to the human rights of affected communities.' (Angelo Jonas Imperiale



Fig. 1 Over Step One - a temporary street art project by Daniele Gottastia (2023) shows the engagement and enthusiasm of people about the progress of reconstruction in L'Aquila and invites to optimism. The streets on which the artwork is located are still covered with temporary asphalt and still need to be paved. (Source: Author, 2024)

and Vanclay 2021) Unfortunately, in some documented incidents, the contrary is the case. Besides genuine helpers, disasters attract speculative companies, which try to capitalize on the catastrophe, get access to emergency or restoration funds, and take advantage of the confusion and urgency.

The example of the reconstruction process of the city of L'Aquila in the Abruzzo region, as documented by Imperiale (Angelo Jonas Imperiale and Vanclay 2021), discloses the mechanisms behind disaster capitalism and how they deflect opportunities to build community resilience after the earthquake. Already before the 2009 earthquake in Abruzzo, the region belonged to the economically weak and marginalized inner areas of Italy. Resulting from the earthquake, seventy thousand people have lost their homes and been moved to tent camps, hotels, and other temporary accommodation in the region. The cities became restricted areas (red zones) patrolled by the military. With people locked out of the centers, in an untransparent way, private companies got the job to take care of rubble, carry out demolitions and shoring-up solutions without consent or knowledge of building owners or inhabitants. (Angelo Jonas Imperiale and Vanclay 2021)

Imperiale argues that the command-and-control approach and top-down planning in L'Aquila annihilated the potentialities of local communities, created additional environmental and social impacts, violated human rights, while worsening vulnerabilities and risks. (Angelo J. Imperiale and Vanclay 2019) Interviews with observers and inhabitants and other sources point to the lack of the empathy or sensibility of workers in charge of the works, as well as corruption and untransparent, infiltration of organized crime, and ineffective use of public funds. (Angelo Jonas Imperiale and Vanclay 2021)

Saving lives comes first. On the one hand, clearing and securing debris routes to access the disaster sites is the necessary step for further rescuing and reconstruction activities, but on the other hand, especially in historical environments, rescue operations need to apply a sensitive approach to dealing with rubble. Although it may not seem so, many of the scattered building materials have historical value and are part of

the local building tradition and part of the identity of the places. In addition, in the interiors of damaged houses other valuable objects (personal value, traditional handicraft) can be undamaged or repairable. Construction workers without awareness of the value of objects and building elements tend to treat them as waste. Also, the debris of structures needs to be treated carefully to protect public health, as some of the materials might contain hazardous substances which need special treatment, e.g. asbestos.

‘The rubble that might be regarded as rubbish by some can be seen by local people as prized possessions full of sentiment.’ (Angelo Jonas Imperiale and Vanclay 2021) The attachment of the building owners to their houses and the remaining materials should be considered an important driver of participatory holistic participatory reconstruction. Inviting inhabitants or appointed representatives to co-decide about their buildings and the surroundings can initiate socially sustainable transformations targeted at reducing vulnerabilities and forming disaster resilient communities.

Empathy Embedded in Rescue Operations

The involvement of building owners in the deconstruction of their buildings could have a strong positive psychological effect on inhabitants affected by a disaster, as shown in the phenomenological study of the psychosocial impact of building deconstruction after the Katrina hurricane disaster in New Orleans, US (Denhart 2009). The study provided information on the feelings of people who had to face the removal of their buildings. Usually, the process is done by tearing down the buildings, shredding, and landfilling the materials, and can be described as technical, mechanical. However, in this case, an international non-profit agency Mercy Corps trained building contractors to make building removal more sensitive and involve owners and facilitated the process of building deconstruction. Thus, it empowers people to take a deliberate sensitive action of dismantling the houses showing respect (as opposed to bulldozing the structure), revealing the value the rubble still has after the disaster, allowing reuse (or donating) of these building materials, as well as being able to part from their buildings and feel excited about the new start. Participants reported a change of mindset from despair to enthusiasm (Denhart 2009). Although not very broad, this study confirms that empathy and compassion in the rubble and damaged structures are essential for victims’ feelings of dignity of victims and important for the reactivation of the community after the disaster.

Different/incoherent approaches to the rescue and reconstruction process in cases of earthquakes in Italy (spanning from 1968 to 2009) enable one to analyze various results achieved and evaluate different preconditions and practices applied (Spano 2017), (Scamporrino 2013). In cases where a strong community or a socially, administratively, or economically well-functioning region was struck by the disaster, the reconstruction process tended to be more successful, fostering communities, and reviving life. The affected municipalities and their inhabitants also had a stronger position in the participatory reconstruction processes, which were managed decentralized. Such were examples of actions after earthquakes in Friuli (1976), Umbria-Marche (1997), and Emilia-Romagna (2012). A rather collaborative approach to participation was implemented with higher levels of municipalities and community empowerment and transparency. In the cases of Belice (1968), Irpina (1980) or L’Aquila (2009), post-earthquake reconstructions were predominantly managed top-down and centralized. Local inhabitants lost contact with the sites and / or other community members due to dislocation further away from their destroyed homes and were excluded from participation, involved in the process too late, or the participative approach, in fact, did not aim to empower people. The lack of transparency, corruption, and the needs of the community led to protests and dissatisfaction after failing expectations and promises. Many of the previous weaknesses of the regions were exacerbated, and problems worsened. Although the above-mentioned cases cannot be compared directly, it is clear that where a more empathetic and interactive approach was chosen, mutual trust was achieved, which led to more satisfactory reconstruction results. The processes in which the preservation of genius loci, the identification of territorial structures, and the valorization of local knowledge and traditions were present helped to foster local communities and provided the impulse to build back better.

Manifestation of Empathy Through Participatory Process

In 1969 Sherry Arnstein published his Ladder of Citizen Participation, where he described eight rungs of possible degree of involvement and empowerment of citizens (Arnstein 1969). The range starts at its lowest by the actual level “nonparticipation”, where the goal is rather manipulation, education or therapy of the participants. Here, the aim is to implement solutions preferred by powerholders through an illusory form of

participation. Further up, on the level, the ‘Degrees of Tokenism’ rungs of informing, consultation and placation describe a deeper involvement of citizens in processes where they can manifest themselves, can hear and be heard, possibly advising powerholders, however, without decisive power over the solutions. The highest part of the ladder is occupied by rungs with increasing degrees of citizen power – from partnership through delegated power to actual citizen control. In these cases, citizens are empowered to (co-)decide (Fig. 2). (Arnstein 1969), (Davidson et al. 2007).

Obviously, the different participation levels serve and predefine outcomes which, based also on transparency, can range from enthusiasm through disappointment to frustration of the involved participating public, having great impact on community recovery and its ability to further develop towards resilience. Top-down approach of management needs to be sensitive about needs of the community and supportive in providing possibilities. Grassroot initiatives must be aware that with empowerment comes responsibility and participation does not mean mere demanding according to individual desires but rather learning, understanding contexts, and growing in the process. Also, participation must be inclusive and empathetically represent vulnerable or disadvantaged groups as well. Inviting unbiased professional facilitators is a good option in situations where traumatization or mistrust is present. Reconstruction after disasters must balance technical, social, and emotional considerations. Empathy ensures that recovery efforts reflect the needs and values of both individuals and communities, resulting in more inclusive and sustainable results. Communities consists of winners and losers, stronger or weaker groups, they are not homogenous. It may not be convenient, but it is essential to involve all groups of the community and create a safe environment for their participation (Twigg 2015) .

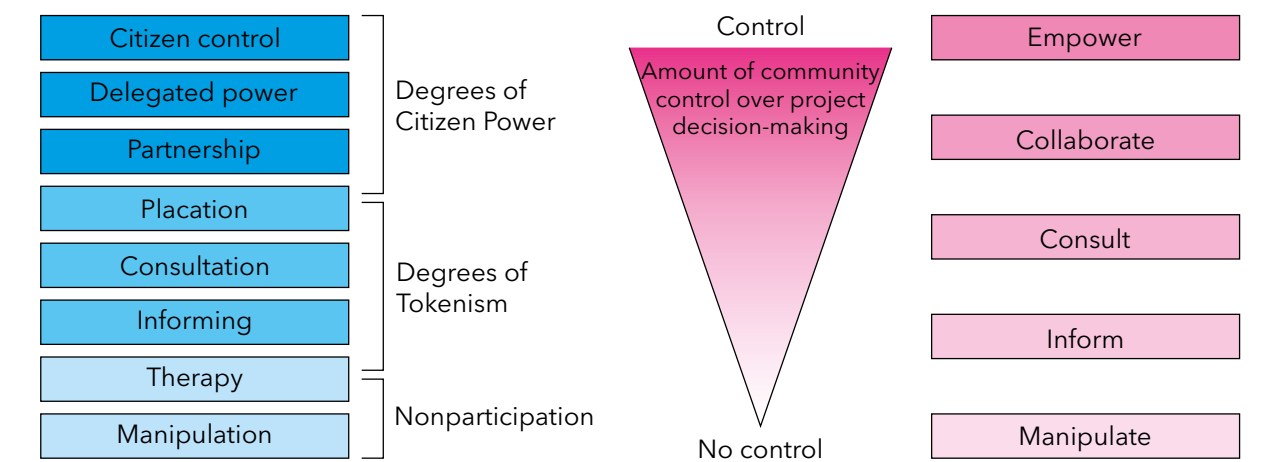


Fig. 2 Ladders of participation - left-hand side according to Arnstein; right-hand side according to Davidson. Source: Author based on (Arnstein 1969) and (Davidson et al. 2007).

Digital Technology and Interactive Tools as Instruments of Reconstruction

Today, digital technology provides documentation tools and nondestructive survey methods which might be adequate for the sensitive approach needed in disaster events. Laser scanning, survey drones equipped with various sensors can be efficient in mapping of damaged structures and rubble, creating documentation like 3-dimensional models, thermographic images, photogrammetric models etc. Photogrammetric models and digital mapping help to document the armed conflict destroyed built heritage in Syria. On the one hand, such documentation can be used for analysis of the extent of damage, causes of structural failure, as well as for identification of scattered building elements by experts. On the other hand, these tools can also provide virtual access to inaccessible disaster sites also for owners, engaging them in early-stage rescue operations and helping identifying values.

Moreover, they can support reconstruction by providing valuable details and helping to categorize and catalogize building elements, as well as in drafting deconstruction and rubble removal plans. Interactive online databases (like, for example, the topotheque [1] together with tools like virtual models or augmented reality can be used for pooling of collective memory.

[1] <https://accumoli.topoteka.net/>

In further steps of participatory planning, these tools can support inclusiveness through easily understandable interactive models as compared to often too complicated and too technical architectural drawings.

The tools together with application of the principles of empathetic and sensitivity approach to reconstructions after disasters, can provide a better link between the distressed community and the helpers, as well as restart the dynamics of the community and engagement of its members in reconstruction processes.

Conclusion

Embedding empathy into policy frameworks and professional training ensures its systematic application. The Sendai Framework for Disaster Risk Reduction promotes participatory approaches and "Build Back Better" principles, emphasizing inclusivity and resilience. Training programs, such as the Red Cross's psychosocial support guidelines, equip professionals with skills in cultural competence and emotional care, enabling them to address the nuanced needs of affected populations in emergency settings. During rescue operations, the development of reconstruction plans or their implementation, the value systems of affected people, their specific vulnerabilities, and the way they perceive their needs must all be taken into account (ICRC 2018).

Empathy can transform rescue operations, enhancing their impact by addressing human experiences beyond technical objectives. Prioritizing vulnerable populations, such as children, the elderly, and people with disabilities—ensures equity in care distribution. Recognizing the sentimental value of personal belongings and memories adds an essential human dimension to debris management and resource allocation. Furthermore, engaging affected communities in decision making during rescue operations helps align urgency with respect for dignity, fostering trust, and collaboration. In fact, applying empathy and sensibility in everyday situations, ie also designing architecture or urban planning under 'standard' conditions, will make it naturally present in extraordinary emergencies, the frequency and severity of which are likely to increase due to climate change.

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VIRTUAL REALITY FOR HISTORICAL HERITAGE

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Abstract

The paper explores the growing role of virtual reality (VR) and augmented reality (AR) in the field of cultural heritage conservation. Technological advances are enabling detailed 3D scanning and modelling of historic sites and the creation of digital archives that preserve cultural assets for future generations. VR enables virtual reconstructions of lost or damaged monuments, bringing history to life and making it accessible to a wider audience. Key benefits of VR include remote access to monuments, protection of originals by limiting physical visits, and the development of interactive educational content that increases user engagement. In addition, VR technology can assist in the preparation of restoration work, minimising the risk of damage to originals and increasing the efficiency of restoration.

It presents specific examples of the use of VR in the conservation of monuments such as Pompeii in Italy, Notre-Dame Cathedral in France and the museum in Mosul, Iraq. These projects offer the public a way to explore cultural heritage without further degrading it, while creating an image of vanished monuments and sites. For example, the reconstruction of war-torn Warsaw through VR shows how this technology can enrich educational programmes and allow users to experience historical realities first-hand.

In conclusion, VR and AR technologies have a crucial role to play in the future of cultural heritage. They not only preserve and make cultural heritage accessible, but also foster innovation and global collaboration. VR is important not only in preserving heritage sites, but also in bringing history to life and presenting it to diverse audiences, ensuring that our cultural heritage remains accessible and protected for future generations.

Introduction – Virtual technologies in general

Virtual reality is used not only in the gaming industry, but also in education, medicine, architecture and many other fields. For construction, architecture and heritage conservation, virtual reality (VR), augmented reality (AR) and mixed reality (MR) have various applications and positive benefits.

Virtual Reality (VR) is a technology that allows users to enter a computer-generated environment that can simulate the real world or create an entirely new one. Users can move around and interact with virtual objects in the VR environment. This is typically done using special VR headsets that have built-in displays and sensors that track head and hand movements. In recent years, affordable headsets with eye-tracking have also come on the market.

VR technologies enable detailed scanning and modelling of historic buildings, architectural monuments, interiors and art objects (Silberman et al, 2012). Using advanced techniques such as photogrammetry and LiDAR (Light Detection and Ranging, which uses laser beams to measure distances and create detailed 3D maps of objects and terrain), accurate 3D models can be created that capture every detail of an object.

The data is then imported into 3D modelling software such as SketchUp or Autodesk Revit, where detailed models are created. These models can be further modified and optimized for VR and AR applications using tools such as Unity or Unreal Engine, etc. In the case of using eye-tracking technology, e.g. WorldViz Wizard, Imotions, i4tracking, Tobii and others are used to record and visualize data.

Virtual models can be enriched with interactive elements and simulations. This includes, for example, the ability to walk around the virtual building, interact with objects, change materials and lighting, or simulate different scenarios such as fire evacuation or restoration procedures, etc. (Champion, 2011). These interactive elements increase the value of VR and AR applications not only by providing users with a deeper and more immersive experience, but also by enabling further study and testing of other development alternatives.

Benefits of using VR for cultural heritage care

Virtual reality can significantly support the learning process, enabling a deeper understanding and strengthening the connection with cultural heritage. In order to achieve this, it is crucial to have a well-defined methodological framework that emphasises recognisability, openness and reliability, while reflecting the specific needs of the target group. These tools allow historians and practitioners to explore in more detail, interpret data, test different theories and run simulations. At the same time, these technologies provide the public with insight into ancient cultures with a broader knowledge and empathy for historical contexts. "The real and the virtual should no longer be seen as opposites, but as a 'continuum' that brings value to cultural and human experience. They involve the observer becoming an active participant with a leading role." (Pietroni et al, 2021)

Virtual reconstruction of cultural artefacts is crucial for the preservation and presentation of historical heritage. Digital models can "recreate" monuments that are physically damaged or lost, offering the public the opportunity to interactively learn about them. Virtual reconstructions not only recreate the image of monuments, but also support users' cognitive processes by allowing interactive viewing, simulations and narrative connections to history. This process expands the possibilities for interpretation and engagement.

The use of virtual reality in the care of cultural (built and historical) heritage brings many benefits, from better preservation and documentation, to improved access and protection, to interactive education and economic benefits (Ch'ng et al, 2013). VR technology has the potential not only to protect our cultural heritage, but also to make it accessible to a wider audience and to foster global collaboration and innovation.

The main advantages are:

- Preservation and documentation of cultural heritage: Virtual Reality (VR) allows the creation of detailed 3D models of cultural heritage sites that can serve as a digital archive in the event of damage or destruction of the original. These digital archives can be used for research, restoration and education, while providing a permanent record for future generations. In the case of high-resolution headsets, VR technology allows even fine details that might be overlooked in traditional documentation methods to be displayed. Using eye-tracking technology, it is also possible to evaluate what elements attract attention and how observers visually perceive the monument.
- Educational potential: Students and researchers can access and explore virtual monuments in detail, making learning and research more accessible (Addison, 2001). Virtual models can be easily shared between institutions around the world, facilitating international collaboration.
- Improving access to cultural sites: Virtual tours allow people from all over the world, including people with disabilities, to visit cultural sites without having to physically travel.
- Protecting originals: VR can reduce the number of physical visits to sensitive locations, reducing the risk of physical wear and tear and damage. In the case of hazardous or hard-to-reach sites, VR tours may be the only way to safely make them accessible to the public.
- Simulation and reconstruction: Users can experience historical events or building monuments in their original form, providing a deeper understanding and experience.
- Interactivity and engagement: VR makes it possible to create interactive learning programmes that can be much more engaging and beneficial than traditional methods by immersing participants in a VR environment and allowing them to interact (Roussou, 2002).
- Economic benefits: Virtual reality can attract more users (students, scientists, tourists, etc.) who may be inspired by virtual tours to visit real sites. At the same time, for museums and cultural institutions, paid VR experiences can be an additional source of revenue.
- Innovation and technology: Investment in VR can support technological advances and innovation in the digital processing and presentation of cultural heritage.

Potential of VR for conservation and restoration of monuments

Virtual reality (VR) offers revolutionary potential for the preservation and restoration of cultural heritage. Thanks to advanced technologies, it is possible to create detailed 3D models of historic buildings and artefacts that serve as accurate digital records. These models can be used to analyse structural damage, plan restoration work and simulate different restoration scenarios without risking further damage to the originals. In addition, VR allows the creation of virtual tours that can reduce the physical pressure on monuments by limiting the number of visitors at sensitive sites. In this way, VR not only helps to preserve and protect our cultural heritage, but also provides an invaluable tool for its accurate and effective restoration.

VIRTUAL RECONSTRUCTION

Virtual reality offers new opportunities for the preservation and restoration of cultural heritage. This technology not only enables the preservation and reconstruction of historical monuments, but also increases their accessibility and visibility. Virtual reconstructions bring history back to life, providing new educational and research opportunities, while ensuring that cultural heritage remains relevant and alive in the digital age.

HISTORICAL AND ARCHAEOLOGICAL CONTEXTS

One of the main benefits of VR technology in the field of cultural heritage care is the possibility of digital preservation of historical artefacts and monuments. Using 3D scanning and photogrammetry, detailed digital copies of these objects can be created, which are then archived and made available for future generations. Digital archives allow researchers and experts to study these objects without the risk of damage and also ensure that information about these objects will be available even if they are physically lost or damaged (Gillings, 2005).

Detailed 3D models of historical monuments and artefacts provide valuable resources for research and analysis. These models can be used to study architectural techniques, materials and construction, helping to better understand the historical context and significance of these monuments. 3D models also allow simulations and analyses that can contribute to restoration planning and conservation (Petrova et al, 2016).

Historical and archaeological contexts are key to creating authentic virtual reconstructions. Archaeologists, historians and heritage professionals work together to interpret and analyse data that provides information about the construction techniques, materials and layout of extinct monuments. This information is then implemented into digital models to ensure their historical accuracy.

Virtual reconstructions can also include aspects that have been lost or are not normally visible. For example, frescoes, mosaics and other artworks that may have been destroyed or faded can be digitally restored to their original form. This process not only returns monuments to their original appearance, but also provides a new perspective on the aesthetic and cultural values of past eras.

RESTORATION OF LOST OR DAMAGED MONUMENTS

Some cultural monuments are physically inaccessible for a variety of reasons, such as their location, structural condition or protection from damage. Virtual tours of these sites also allow them to be viewed and studied without the need for a physical visit. These tours can include interactive elements such as information points, videos and 3D models, providing a deeper insight into the history and significance of the site or monument.

Virtual reality also serves as a supportive environment for planning the restoration of lost or damaged monuments through advanced 3D modelling techniques and historical data (Forte, 2014). Digital reconstructions represent a significant advance in the field of heritage conservation, as they allow professionals and the general public to see and experience monuments again in their original form. The process begins with the careful collection of historical information, including old photographs, plans, paintings, written records and eyewitness accounts, which provide the basis for creating accurate 3D models that faithfully reproduce the original appearance and structure of the monuments.

EDUCATION

Virtual reconstruction also serves as an important tool in education, especially in the fields of art history, archaeology and cultural heritage. It allows interested people (students) to explore historical sites and artefacts that would otherwise be inaccessible. Interactive content, such as simulations, 3D models and

virtual laboratories, allows for hands-on experiments and exploration of theoretical concepts, increasing student engagement and promoting a deeper understanding of topics. They are also a valuable resource for research, allowing professionals to test hypotheses about building techniques, materials and space use. Students of history, archaeology and art can thus study details that would otherwise be inaccessible.

VIRTUAL MUSEUMS AND EXHIBITIONS

Virtual museums and exhibitions allow users to view cultural heritage from the comfort of their own home. Using VR technology, it is possible to 'visit' museums that would otherwise be out of reach and view exhibits in 3D with a high level of detail. Virtual exhibitions can include interactive elements such as information points, multimedia content and interactive objects to provide visitors with a deeper and more immersive experience. This allows museums to reach a wider audience and increases awareness of important cultural artifacts and sites (Economou, 1999).

TOURIST AND COMMERCIAL APPLICATIONS

Virtual reconstructions of monuments can serve as an important tourist attraction. Virtual tours can attract visitors from all over the world, allowing them to experience historical sites without having to physically visit them (Styliani et al, 2009). This approach is particularly valuable for sites that are geographically remote or have limited accessibility. Virtual tourism can also contribute to the protection of physical sites by reducing pressure on sensitive areas.

Commercial applications of virtual reenactments can include the creation of interactive apps that allow users to explore historic sites through smartphones, tablets and VR headsets. The benefits of these apps include the ability to implement audio-visual commentary, interactive elements and other content to enrich the user experience. The commercial success of virtual applications can also generate funds that can be reinvested in other cultural heritage conservation and restoration projects.

SIGNIFICANCE FOR THE FUTURE OF CULTURAL HERITAGE

Virtual reconstruction of lost or damaged monuments is of great importance for the future of cultural heritage. By enabling the creation of accurate and detailed reconstructions, it ensures that historical and cultural values are preserved and made accessible for future generations. Virtual models can serve as valuable resources for education, research and public awareness, contributing to a deeper understanding and appreciation of the past.

MONITORING AND MAINTENANCE

REAL-TIME MONITORING THROUGH VR AND AR TECHNOLOGIES

VR and AR technologies together with real-time monitoring can also be used to predict the deterioration of materials, structures and other components of historic monuments. Sensors placed on buildings and artifacts can collect data on their condition, such as temperature changes, humidity, vibrations, or structural movements. The collected data is then fed into a detailed 3D virtual model where changes are monitored and analyzed in real time. In this way, experts can not only monitor the condition of monuments, but also predict potential problems such as cracks, degradation, erosion or other forms of damage. By integrating sensors and data analytics tools, experts can gain detailed information about the condition of monuments and better understand how different factors affect their long-term stability. For example, changes in temperature and humidity can have a significant impact on the materials from which monuments are made. This predictive approach allows preventive measures to be taken early, maintenance and restoration work to be planned with high precision and efficiency, minimising the risk of damage and helping to protect and preserve these valuable objects for future generations.

In addition, the virtual environment allows simulation and testing of different methods and identification of the most suitable solutions for specific situations, which reduces the risk of damage to monuments during restoration and rehabilitation work and increases the efficiency of the entire process. Virtual simulations allow experts to test and evaluate different restoration techniques without having to intervene in the monument itself. This process not only reduces the risk of damage during actual restoration work, but also increases the efficiency and accuracy of these interventions.

Overall, VR and AR technologies therefore represent innovative tools for the preservation and maintenance of historic monuments. They enable detailed monitoring, accurate maintenance planning, wear prediction and efficient simulation of restoration works. The implementation of these technologies contributes significantly to the long-term preservation of cultural heritage and its accessibility for future generations.

Examples of the use of VR in the care of cultural heritage

A number of virtual environments are currently available around the world that try to bring historical monuments closer to the visitors. A major driver in the development of VR technologies for research, education, entertainment and tourism has been, among other things, the Covid-19 pandemic, which has accelerated the need for access to historic buildings and artistic artefacts. The following is a very brief selection of a few diverse examples, mainly from the European environment. The examples below are linked by a 'catastrophic context'. That is to say, VR was created for these examples not only to preserve the image of the site before the disaster – war or natural disaster – but also, in many cases, to elaborate on the possibilities for future development of the sites concerned.

ITALY: POMPEII

Pompeii, an ancient city destroyed by the eruption of Vesuvius in 79 AD, was one of the first locations where virtual reality was used to reconstruct historical monuments (<https://www.pompeiidiscovery.com/>). Thanks to advanced technology, detailed 3D visual models of the city have been created, allowing visitors to explore the city as it looked before its destruction. The virtual reconstruction includes buildings, streets, house interiors and even original frescoes and mosaics.

Virtual reality is also being integrated into educational programs and tourist tours of Pompeii. Visitors can use VR headsets that allow them to walk around the ancient city and see what the interiors and exteriors looked like before the disaster. These virtual tours are complemented by audio commentaries and interactive elements that provide deeper insight into the lives of Pompeii's inhabitants. Special educational programs are available for schools and universities that combine VR experiences with historical facts and research (Fig.1).



Fig. 1 Promotional photos from the virtual tour of Pompeii with a headset (<https://www.pompeiidiscovery.com/gallery/>).

FRANCE: NOTRE-DAME CATHEDRAL

Following the devastating fire at Notre-Dame Cathedral in 2019, 3D scanning and VR technology were used to document and plan the reconstruction (<https://www.flyview360.com/en/experiences/notre-dame>). Detailed 3D models of the cathedral were created based on previous scans and photographs, allowing for the preparation of an accurate reconstruction of the damaged parts. These models are used by architects and restorers to plan and coordinate reconstruction work.

Virtual reality also allows the public to follow the progress of the cathedral's restoration. Virtual tours and interactive models give visitors the opportunity to see how the cathedral's reconstruction is progressing and to learn more about the techniques and materials being used. This ensures transparency and public involvement in the restoration process (Fig.2).



Fig. 2 VR insight into the reconstruction of Notre Dame Cathedral is a way to raise funds for the restoration (<https://www.flyview360.com/en/experiences/notre-dame>).

IRAQ: MOSUL

A collaboration between The Economist Media Lab and Rekrei produced a VR reconstruction of the Mosul Museum, many of whose artefacts were destroyed during the ISIS occupation of the city in 2015. This VR experience allows visitors to walk through a virtual replica of the museum, see the original artifacts, and learn more about the cultural heritage that was affected by this tragedy. The app is available via Google Cardboard for Android and iOS, and also in 360° format on YouTube and Facebook, making the experience accessible to the general public, who can learn more about the city's history (<https://visualise.com/case-study/recover-mosul-a-collective-reconstruction>).

POLAND: WARSAW

The Museum of the Warsaw Uprising offers a VR experience "Scenes From World War II", which transports visitors to wartime Warsaw. More information about the project can be found on the UploadVR and SSVAR websites. VR technology has been used to reconstruct destroyed sites in Warsaw, especially after World War II. The projects serve to educate and present the city as it looked before the bombing, which is used by museums as well as tourist and cultural organisations (<https://www.uploadvr.com/warsaw-uprising-museum-using-vr-put-people-wwii/>).

Another app shows an alternative history of Warsaw with buildings that were supposed to be built before World War II but were never completed (the so-called Crossed-Out Warsaw). This project can be found on Culture.pl (<https://culture.pl/en/article/the-warsaw-that-wasnt-using-vr-to-explore-a-city-denied-by-wwii>).



Fig. 3 The World War II museum in Warsaw is using VR to bring its visitors to the war-torn streets of Warsaw for an atmospheric experience that they won't soon forget (<https://www.uploadvr.com/warsaw-uprising-museum-using-vr-put-people-wwii/>).

Conclusion

The benefits of using VR technology in cultural heritage care are manifold and include the areas of education, accessibility, documentation, identification of valuable features, restoration and reconstruction. Virtual technologies offer new opportunities for engaging the wider public, inclusion of people with disabilities and the preservation of historic monuments and artefacts. These technologies enable the creation of detailed digital copies of monuments using 3D scanning and photogrammetry that can be archived and made available for future generations. The digital archives created provide valuable resources for experts, allow the study of objects without the risk of damage, and ensure the preservation of information even in the event of physical loss or damage to the originals.

Real-time monitoring and maintenance planning are other key areas where VR can bring significant benefits, such as tracking the condition of monuments and predicting the restoration interventions needed. The implementation of these technologies can contribute significantly to the long-term protection and preservation of cultural heritage for future generations.

Examples of the use of VR technology in the care of cultural heritage in Europe show how virtual reality can enrich and make history accessible to a wide audience. Virtual reconstructions, interactive tours, educational programmes and online platforms provide new opportunities for the preservation and promotion of cultural heritage. Interactive elements such as information points, videos and 3D models provide deeper insights into the history and significance of individual monuments. The implementation of these technologies provides new opportunities for education, public engagement and the protection of historic monuments and artefacts. Virtual reality thus represents a valuable tool for the preservation and dissemination of cultural heritage that can reach a wide range of users and ensure that our history is accessible and protected for future generations.

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TECHNOLOGICAL SURVEYS AS POTENTIAL BASIS FOR A COMPLEX PARTICIPATORY RECONSTRUCTION

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Abstract

Technological advances in the recent two decades like the off-the-shelf availability of affordable unmanned aerial vehicles (UAVs) equipped with a multitude of sensors capable of capturing surface geometry and other properties of the environment on a large scale have not only revolutionized the field of surveying and mapping. 3D laser scanners have become more affordable, portable, and more user-friendly in recent years. It is obvious that 3D mapping and reconstruction techniques can and are actually applied in the context of disasters like earthquakes. Drones are already being used very successfully by emergency services to gain an initial overview of the situation quickly, inexpensively, and without risk to themselves and later, e.g. in the search for missing/buried persons, but they can also be used to record data for 3D documentation if the recordings fulfill certain quality criteria. This article aims at giving an overview on 3D documentation technology and their potential application to disaster affected communities using an example from the city of Accumoli, which was hit by a catastrophic earthquake in 2016.

Continuous 3D Documentation

The image and video material captured after the incident is a valuable source of information since it documents the scenario created by the disaster in its original form before human intervention like the use of construction machinery when searching for victims, which is inevitably invasive. It goes without saying that saving human lives takes precedence over interests such as the physical preservation of (fragments of) buildings and measurements capturing their geometry and their positional relationship, which are helpful for reconstruction purposes later on. Nevertheless, early and as comprehensive as possible documentation of disaster areas can later be valuable in many ways. Therefore, it is worthwhile to carry out these tasks in such a way that the data can later be used for, e.g. 3D reconstruction. This is the case if automatic aerial surveys are performed in a systematic fashion using high quality cameras to be able to compute complete high-resolution 3D digital environment models (DEM) using image-based modeling techniques provided by software tools like RealityCapture or MetaShape (1, 2). Alternatively, airborne laser scanning (ALS) can be employed. In the past, ALS surveys required airplanes to carry the heavy laser scanners. Nowadays, ALS surveys can be realized with increasingly smaller and lighter drones. The latest generation laser scanners are compatible with drones typically used by first responders (3). First drones with integrated laser scanners are available (4). It is to be expected that more will come onto the market in the coming years, which will further lower the threshold for early 3D documentation and to even use drone-mounted LiDAR for search and rescue missions (5). Further benefits of continuous 3D documentation include the automated recognition of damage and assessment of building structures based on the 3D data (6).

Image-Based Modeling versus LiDAR

Reconstruction of 3D geometry from 2D images is an indirect measurement that relies on the correct identification of correspondences in image pairs using computer vision techniques. Finding such corresponding features may and in practice do fail depending on numerous factors like target surface properties and lighting conditions. Mismatches inevitably affect the accuracy of the resulting 3D. Aside from that, determining the absolute scale requires known real-world distances. The availability of drones and cameras equipped with RTK GNSS positioning systems has put this fact to the background. In general, cameras are still much cheaper and easier to use than 3D laser scanners. Even if the geometry has errors in detail, this can be masked by superimposing the color information from the mostly high-resolution images. In contrast laser scanners measure are based on direct distance measurements, which leads to highly accurate geometry, while recording surface properties like color requires an additional optical sensor. Nevertheless, the resulting 3D point clouds are non-continuous sparse 3D representations only defined at the respective measurement points. Surfaces can be obtained in post-processing, by locally fitting planes and combining them to meshes.

Ideally, both computer vision-based 3D reconstruction and laser measurement are combined, which is supported by popular multiple-view 3D reconstruction software like RealityCapture or Metashape (1, 2). Leading manufacturers of airborne 3D laser scanners and aerial images teamed up to develop multi-sensor and software solution for remote sensing (7).

Terrestrial Methods

The quality of 3D depends not only on the resolution and accuracy of the underlying recording methods. Model completeness is another quality feature, which can be hard to achieve in complex scenarios such as a disaster theater compared to an open field where overlapping aerial images taken with the camera facing down suffice. In urban areas, the presence of vertical surfaces like facades requires imagery from oblique views, which can only be obtained in flights close to the ground in the streets. Model holes caused by obscuring structures can only be avoided by including images in which the target surfaces are visible. In confined spaces, this can only be achieved using terrestrial measurements. In principle, it is possible to carry out additional measurements or recordings from the ground as long as the safety of the actors is not jeopardized and rescue operations are not disrupted. In the former case, image acquisition and measurement tasks can be supported by unmanned remote controlled or autonomous vehicles (UGVs or AGVs).

Monitoring

Frequent and repeated 3D documentation throughout the rescue, clean-up, and demolition phase, but also during reconstruction, can be part of a targeted monitoring process. In an earthquake scenario, this approach also makes it possible to document structures initially buried under rubble and their location. This enables the creation of databases for storing where and when certain fragments of interest were found and where they were later taken for storage. A carefully 3D documented teardown has parallels to an archaeological excavation. Therefore, tools for documenting the stratification can be applied (8), which could be used to reconstruct the temporal order in which buildings collapsed.

3D Documentation of Accumoli

In May 2024 as part of the ComPaRe project, a comprehensive 3D documentation of the city center of Accumoli was performed to evaluate the basic suitability of current technologies for 3D documentation at a real scene of a severe earthquake. This experiment carried out almost 8 years after the disaster naturally only provides direct information on the applicability of 3D documentation methodology in a phase in which a large part of the clean-up and stabilization work has already been completed and reconstruction is already underway. However, the measurements carried out allow conclusions to be drawn about the requirements and possibilities in the immediate event of a disaster.

Image acquisition for image-based modeling was largely performed using a drone weighing approximately 900g (DJI Mavic 2 Pro) and a much smaller 250g drone (DJI Mini 3). The former is equipped with a high-quality lens and was primarily used to take images from approximately 30 to 50 meters above the ground based on a flight plan ensuring image overlap of 60 to 80 percent. The images were taken at different viewing angles. In addition to views perpendicular to the ground, which are commonly used in 3D mapping applications, oblique views at 45 degrees were added to obtain better image material for the reconstruction of vertical surfaces like a facade. The smaller drone was mainly used to be able to add more detail to facades and better texture information for the reconstruction of buildings of high interest such as the city tower. Furthermore, the small drone was used to take images in areas corded off for safety reasons, like in or close to remaining walls of partially collapsed buildings. 3D reconstruction was performed using RealityCapture (1).

Terrestrial Laser Scanning Experiment

One main of the measurements in Accumoli was to test the latest terrestrial laser scanner introduced by Riegl Laser Measurement Systems, the VZ-600i (9), which has a number of properties, which are very useful for quick 3D documentation under spatio-temporal restrictions, without sacrificing the achievable quality of the resulting 3D model.

First of all, there is no need to place markers to be able to perform the registration and fusion of single scans to a 3D model, which could be very dangerous in the post-disaster situation. The VZ-600i is equipped with a motion sensor (IMU), which records the relative motion between scan position, which is a sufficiently accurate initialization for high-precision registration algorithms in post-scan processing.

Furthermore, the generally lightweight construction of the scanner makes it possible to move from one position to the next one quickly and safely, even on uneven surfaces and in confined areas. The manufacturer promises up to 60 scan positions per hour. For a post disaster scenario, these numbers are a bit too optimistic. Still, we managed to record more than 420 scan positions in two working days, 12 hours of net scanning time.

Scanning could be carried out by a single operator, apart from particularly impassable positions on rubble heaps and in the midst of the vegetation that is now lushly overgrowing the ruins, where one helper was required to pass the scanner setup to the operator (Fig. 1 and 2).



Fig. 1 Laser scanning in Accumoli using the Riegl VZ600i. This scanner is much faster than previous models, allowing up to 60 scans per hour. This is mainly due to the possibility of moving it from one scan position to the next one very quickly, because of its lightweight construction and possibility of markerless operation.



Fig. 2 Scanning in a position in gravelled alleys and other areas almost completely reclaimed by nature. Scanning is possible as long as the scanner and the optional tripod can be set up stably. The distances between the scan positions are chosen based on the geometric complexity of the environment and typically range between 5 and 15 meters.

Terrestrial Laser Scanning Results

Fig. 3 shows the uncolored fused 3D point cloud from a bird's eye view. The main streets and alleys are clearly visible, as they were clearly best covered by the easy accessibility. The black regions in the image indicate missing data. Such regions were not hit by laser beams from any of the scan positions. A more complete model could only have been achieved by adding scan positions from the interior of partially collapsed buildings, collapsed ceilings and cellars, etc., which we avoided for safety reasons. These areas were secured with fences and barrier nets. However, airborne laser scans could have been used, but were not carried out for the time being, due to the great administrative effort required for authorizations for flights with the existing RiCopter (10), a large drone carrying a special laser scanner.

Fig. 4 and 5 show oblique aerial views from of the city center and tower of Accumoli. The 3D point cloud is of high quality. There were no registration errors for 419 of 420 scan positions. One scan could not be registered because the registration software detected the motion of the scanner during the scan. However, the model is of good quality and complete thanks to the careful choice of scanning positions. Careful choice of scan position minimizes the number of scans required without sacrificing the quality and completeness of the resulting model. Experienced laser scanner operators intuitively observe the environment, recognize objects in the beam path of individual scan positions, and select new scan positions in such a way that the missing information is supplemented without redundancy if possible. This leads to practices such as scanning before each door and window opening and at branching alleys. Elevated scan positions are useful to scan roofs in the absence of airborne data. Some regions not physically accessible for scanning could be scanned from elevated positions 100 meter farther away. Others, such as recessed cellar vaults at risk of collapse, could be scanned from the outside using a larger number of scanning positions close together.



Fig. 3 Overview: 3D laser scan point cloud showing the scanned regions in the center of Accumoli. Black spots in the center of the images indicated regions, which were inaccessible for laser beams from far away and to the human operator for safety reasons, e.g. danger of ceiling collapse, falling building parts. These places were secured with fences and barrier nets..



Fig. 4 3D laser scan point cloud region showing the center of Accumoli including the city tower and nearby buildings and ruins. The scans also show artifacts caused by people crossing the line of sight of the scanner. Such artifacts can be removed in post-processing..



Fig. 5 Oblique view of the city center and tower from a virtual viewpoint. This view clearly shows that it was not possible to cover all roofs, courtyards, and interior rooms of destroyed building from safe terrestrial scanning positions. Some of the missing data could be supplemented by airborne laser scanning or image-based modeling.



Fig. 6 Detail views of the high-resolution point cloud computed using the 420 scans recorded by the VZ600i. The target point density is below one cm. Due to the high scanning precision and the advanced registration fusion techniques, the resulting point cloud is also highly accurate with seamless transitions between the individual contributing scan positions. Details such as mortar joints, door and window fittings and even knotholes in wooden beams are defined both in terms of color and geometry.

Conclusions

The experiments in Accumoli more than a decade after the devastating earthquake series have shown that 3D documentation in disaster areas does not have to be limited to photogrammetric reconstruction based on aerial footage and airborne laser scans from the air, although these are probably easier to implement soon after the disaster. Terrestrial laser scans can also be carried out at the latest after the rescue of victims and initial safety measures, taking operator safety into account. Although complete coverage of the scenario is not possible from safe scanning positions, terrestrial laser scans provide data from other positions that would not be possible from the air. In combination, this results in more complete models. Due to their ease of use and low weight, modern 3D laser scanners can be operated efficiently by a maximum of two people, even on difficult surfaces, further minimizing risks. However, it would be desirable to eliminate the remaining risks for human operators. The resulting images and 3D documentation have potential to unveil the inaccessible disaster sites to the owners and residents and it can be used as a basis for a complex participatory reconstruction. In participation workshops guided by experts (architects, urban planners, sociologists...) the images can support the identification process of building elements, spatial contexts as well as historical values of the sites. This approach can be applied in a safe and controlled environment and can induce discussion and support collective memory or provide guidance where little or no documentation of the original state is available.

Outlook

The HERITAGE-Ross research project (Robotic Operated Multi-Sensor System) aims at the development of novel integrated and highly automated sensing techniques and platforms for digital Cultural Heritage documentation and monitoring. The core objective is to develop a largely autonomous robot platform as a carrier device for many sensors, including a terrestrial laser scanner.

This sensor platform, implemented on an all-terrain tracked vehicle, will enable an even wider use of terrestrial laser scanners in disaster areas. Scanning positions on cones of rubble, in or around buildings at risk of collapse, would thus be possible.

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REBUILDING THE MEMORY. DIGITAL TECHNOLOGIES AND PARTECIPATORY PROCESS FOR DATA COLLECTION IN A COMMON DATA ENVIRONMENT

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Abstract

The article explores the importance of an integrated methodological approach for data acquisition, combining direct field surveys and indirect analysis through historical and documentary sources. In post-emergency contexts, advanced technologies such as Terrestrial Laser Scanning (TLS) and aerial photogrammetry allow for the collection of detailed and quantitative information about the built heritage, facilitating damage assessment and reconstruction. Instrumental surveys provide precise three-dimensional models, which, combined with sociocultural data gathered through interviews with residents, enable a comprehensive understanding of territorial transformations. Additionally, the adoption of tools like Building Information Modeling (BIM) for 3D modeling enhances the reconstruction process, improving planning, cost management, and future building maintenance. Rapid surveying, supported by documentary and technical data, plays a crucial role in safety assessments and seismic vulnerability evaluation.

Introduction (T.E.)

The recent seismic history has highlighted two important needs: obtaining quick responses regarding the extent of the damage and the habitability of structures affected by exceptional events, and preserving the material and immaterial heritage that has been partially or entirely lost. Therefore, a methodology has been developed that starts with building a knowledge framework through the direct and indirect acquisition of information.

Direct knowledge involves gathering information in the field through integrated and rapid surveys. These are geometric, material, and structural data that are useful in the initial phase for safety operations, and in the second phase for damage assessment and supporting decision-making processes to define the new configuration of the destroyed places.

Indirect knowledge involves the acquisition of information of various types, such as historiographical, cartographic, archival, photographic, and textual, which can have a dual purpose. Some parts complete the scientific framework for understanding the territory, like technical maps, while others help preserve the immaterial values that characterize it, such as interviews.

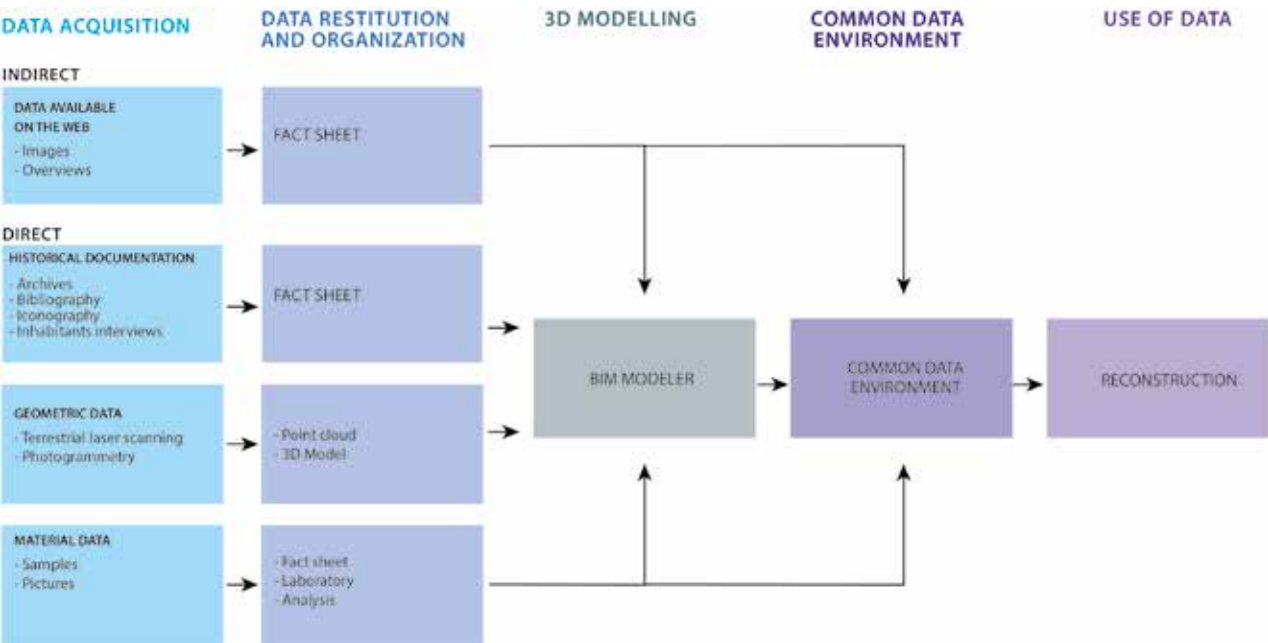


Fig. 1 ARIM Workflow.

The processing and systematization of the collected data, along with their structured use, leads to the definition of a procedure called Assessment Reconstruction Information Modeling (ARIM). At its core is a data-sharing environment called the *Common Data Environment (CDE)*, which enables the generation of informed models aimed at managing the current state and the reconstruction of what has been lost, while ensuring the perpetuation of material and immaterial values within the community.

The ARIM procedure integrates some of the processes derived from *Building Information Modeling (BIM)*, such as *GeoBIM*, *HBIM*, *LIM*, and *Seismic-BIM*, and represents a natural evolution in which these procedures have a more focused scope.

The acquisition of information from indirect sources is based on identifying open-source data. There are open-access databases available on the web that can be useful for obtaining essential information for all phases following emergency management.

Among these, Google Maps can be used to download navigable spherical panoramas from Google Street View(Reluis, 2014) (Fig.2). Two levels of information can be obtained from them:

- 1. They allow the visualization of the previous state of the site in three-dimensional form, providing a view of the reality that no longer exists, which is essential for tracing the main locations of the site that constitute its representative image;
- 2. They enable, through procedures for reprojecting the equirectangular image, the extraction of metric information on buildings that no longer exist.

From technical maps (Ciccaglione, 2019) (Fig.3), on the other hand, it is possible to acquire a great deal of information about the geological composition of the land and the seismic microzonation of the area. Some of these also include typological analyses of existing buildings, which are extremely useful in identifying real estate and heritage buildings.



Fig. 2 Data from spherical panoramas of Google Street View, Google (c).

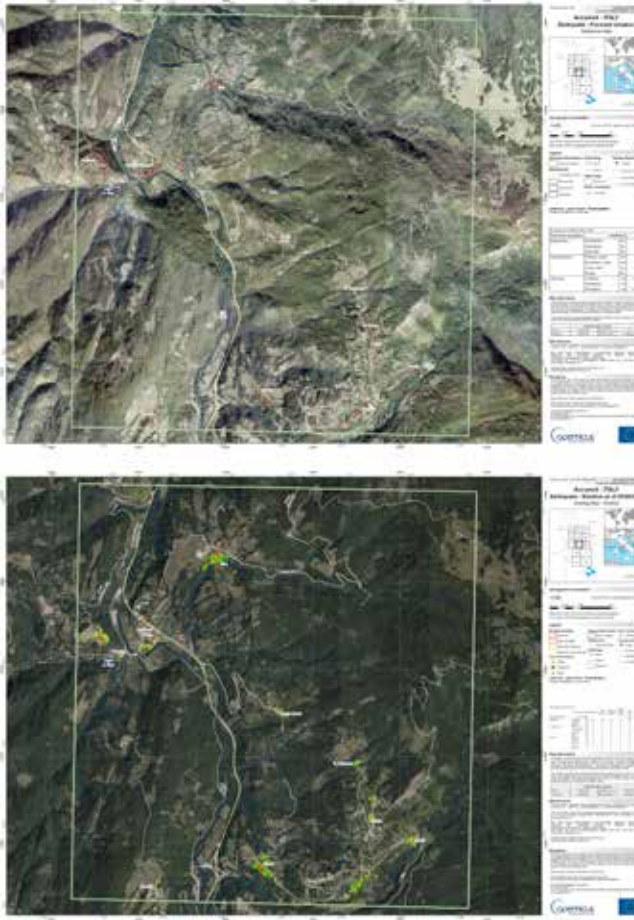


Fig. 3 Data from Copernicus and technical maps, <http://dati.lazio.it/catalog/it/dataset/carta-tecnica-regionale-2009-5k-rieti>.

Direct Data Acquisition (A.C.)

HISTORICAL DOCUMENTATION

In order to obtain a thorough understanding of the evolutionary dynamics of the built environment and urban landscape, an integrated methodological approach is adopted. This approach involves, on one hand, a direct field investigation that allows for the characterization of physical components and the monitoring of ongoing transformations. On the other hand, an indirect analysis, based on the examination of historical and documentary sources, helps to reconstruct the historical evolution of the examined territory, providing a fundamental framework for interpreting the data acquired in the field and for understanding the causes and methods of the observed transformations, thus contributing to the contextualization of direct observations.

As for the historical documentary analysis (indirect analysis), in small villages located in the Apennines, documentation is often scarce or absent, as well as iconographic sources. Some of the information can be found in private archives of the residents. However, cartographic and iconographic research is mostly effective for acquiring quantitative and qualitative data and information related to the tangible components of urban fabrics and territories. It is essential to integrate these approaches with more in-depth investigations into the sociocultural and perceptive dimensions of the places. The study of the composition and dynamics of the social fabric, along with the analysis of residents' perceptions of the spaces, represents an indispensable element for a complete and multidimensional understanding of territorial systems, particularly in the context of reconstruction and urban regeneration processes. In this regard, interviews with residents are a fundamental tool for collecting empirical data on perceptions, physical configurations, mental representations, and individual experiences, contributing to a more accurate and nuanced reconstruction of the social fabric and territorial dynamics (Ciccaglione, 2019) (Fig.4).

Geometrical Data

The survey, which is both deferred and indirect, is accompanied by instrumental surveying, which allows for a deep understanding of the subject of study—i.e., the acquisition of information that goes beyond the perception of our senses. This methodology forms the basis for constructing models, understood as representations of complex phenomena, capable of encapsulating the intangible and tangible heritage affected by seismic events.

In post-emergency situations, the need to collect as much data as possible in a short period of time is addressed through the procedure of mass data acquisition. The result is point clouds, on which the necessary discretization

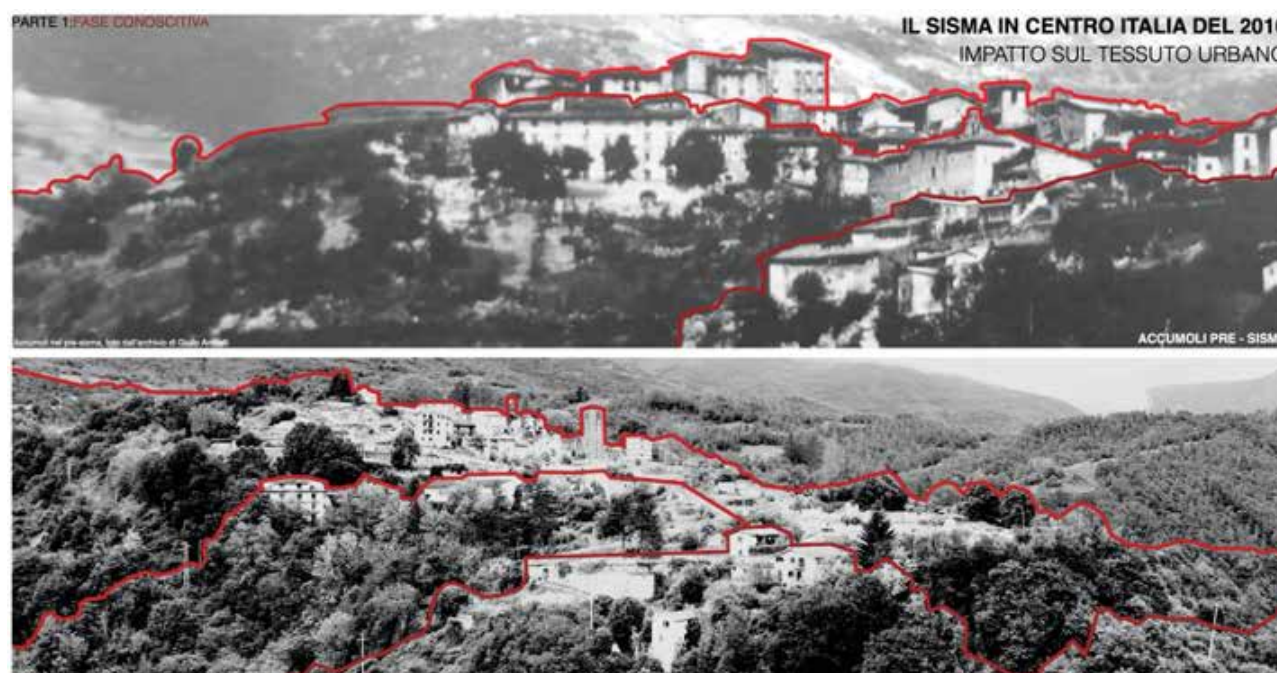


Fig. 4 Knowledge Framework, image of Accumoli before and after the earthquake from the south.

operations for restitution are carried out later. This survey is also called instrumental, as it does not involve direct contact with the object itself, and integrated, as it is based on the use of multiple tools (in this specific case, Terrestrial Laser Scanning and Aerial Photogrammetry), whose data are complementary and integrable.

Generally, the procedure includes:

1. Gaining familiarity with the subject of study by collecting as much information as possible about the place and/or individual architectural object;
2. Defining the objectives of the survey;
3. Choosing the instrumentation;
4. Acquiring the data (surveying);
5. Processing and discretizing the data (survey);
6. Communicating the information, in line with the purpose of the survey.

Terrestrial Laser Scanning (TLS)

The Terrestrial Laser Scanner is a device that uses the emission of electromagnetic waves, specifically laser (Light Amplification by Stimulated Emission of Radiation), in rapid sequence in the form of an ideal sphere, to acquire the position of points intercepted by it. Consequently, the points will be more dispersed the larger the radius of the sphere.

Laser Scanners can be divided into:

- Short range: to investigate the detail scale;
- Long range: to investigate the architectural scale.

Depending on the method used to measure the points of the object, Laser Scanners can also be distinguished into:

- Time of flight: To position a point in space, the Laser Scanner measures the time it takes for the beam to travel to the object and back;
- Phase difference: To position a point in space, the Laser Scanner measures the wavelength difference of the outgoing and returning beam. The reflection from the intercepted object alters the phase characteristics of the electromagnetic wave. Due to the faster data acquisition capabilities of these tools, they are generally used for dynamic applications with the use of mobile supports. Lidar, for example, can be an effective tool for rapid data collection in urban environments.

Through Laser Scanner acquisitions, we can obtain five different types of information: three Cartesian coordinates, the RGB data of a photograph, and the reflectance, which refers to the amount of light that returns to the instrument after the laser waves have struck its surface.

The acquisition process is divided into a precise sequence of phases:

1. Survey project: Analysis of the survey area with the drawing and definition of the geometry of the space through the creation of two-dimensional and three-dimensional eidotypes on which annotations can be made;
2. Acquisition of scans: Maximum coverage, constant accuracy, and minimal station setup with attention to visibility between them and the inclination of the station point. During this phase, where possible, special targets should be used for the connection between individual scans and the data to be collected with further instrumentation. If conditions do not allow for this, it is advisable to identify in advance and ensure the correct capture of significant points to be used during the data processing phase;
3. Processing of scans: The scans produce partial point clouds, which are then merged in this phase. The procedure can be done directly by positioning the obtained scans based on known georeferenced points, for example, acquired through topographic surveying or GPS. Indirect registration involves using targets or overlapping at least 30% of the point clouds, considering the possibility of georeferencing the survey using known GPS coordinates or existing topography (Fig.5).

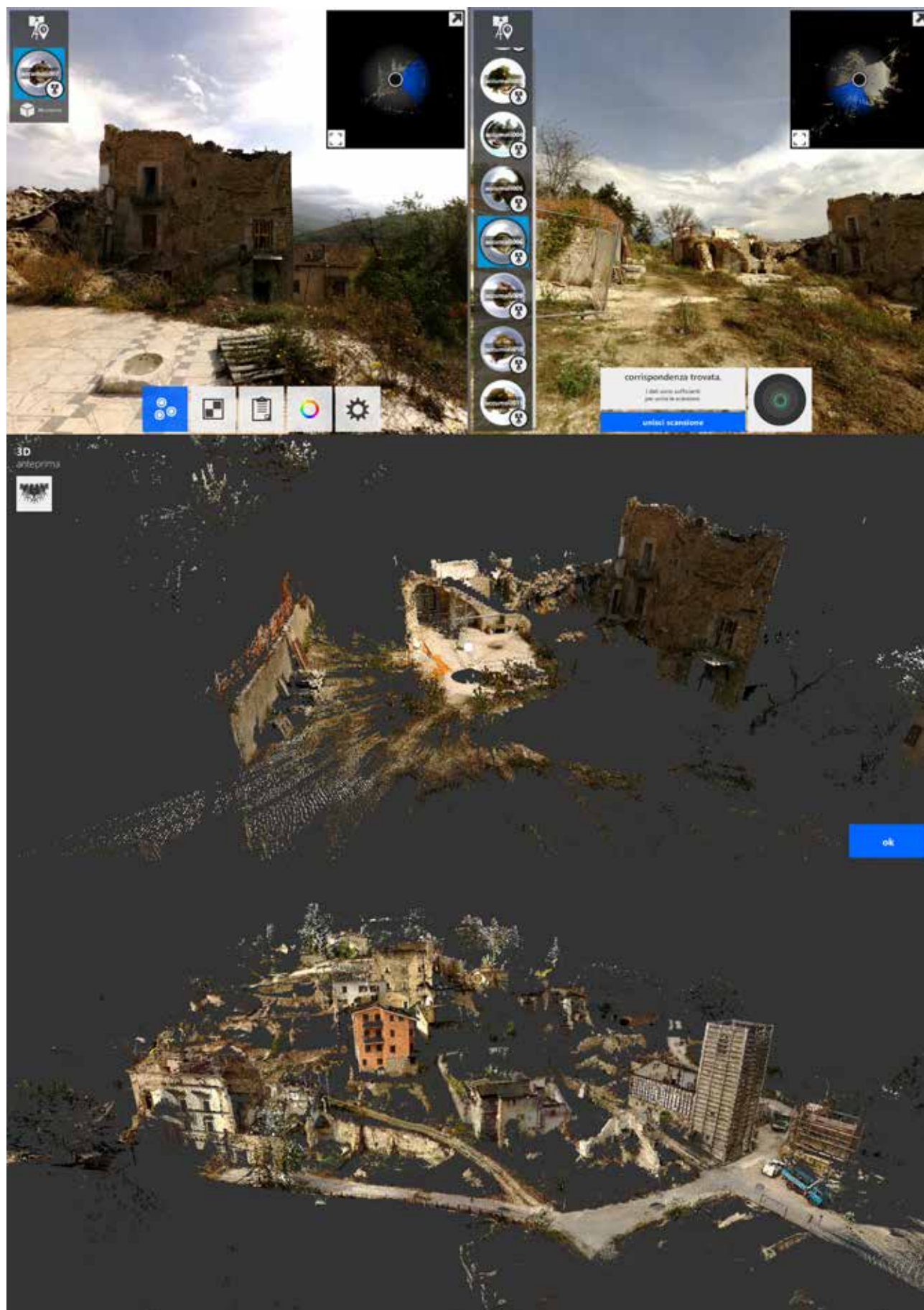


Fig. 5 Procedura di acquisizione da Laser Scanner ad Accumoli ottobre 2023.

Aerophotogrammetry

Photogrammetry and aerial photogrammetry are based on the Structure from Motion technology, which uses an algorithm to extract metric data derived from the processing of stereometric photographs. In fact, the parallelism between photogrammetry and the principles of projective geometry is well known, according to which it is possible to derive the real dimensions of objects and their spatial location based on their position relative to the center of a photograph. However, this is only possible if the investigated point is homologous, meaning it belongs to at least two sequential photographs.

The most important variables to consider when taking photographs are:

- Focal length: the distance between the sensor and the lens system of the camera. This is a theoretical value that considers the lens as a single element rather than a system of lenses;
- Capture center: the center of the lens system;
- Principal distance: corresponds to the focal length.

The need to take photographic sequences and ensure the homology between points arises from the assumption that there are infinite real points that could correspond to the projected ones. Therefore, photogrammetry reconstructs the three-dimensional coordinates of real points (A, B, C) from those projected onto the sensor, if and only if there are at least two frames that capture the same point. In this way, the projective lines of the sensor's points intersect, determining the exact coordinates of the real point.

The widespread use of drones or *Unmanned Aerial Vehicles (UAVs)* has made aerial photogrammetry a common practice in surveying. This allows the integration of ground data with data describing areas that are difficult to reach (such as high positions or roofs). It plays a crucial role in post-emergency situations, where often isolated or hazardous areas are created due to building instability, debris, or geomorphological conditions. In addition to this specific utility, aerial photogrammetry enables the production of topographic maps, *Digital Terrain Models (DTM)*, orthomosaics, thematic maps (geological, hydrogeological, etc.), maps for regional and municipal urban planning (*CTR*), and environmental and cadastral surveys.

Aerial photogrammetry provides a real-time view of areas affected by the earthquake, offering data related to the damage state, but above all, it preserves an image of places that may no longer exist in the reconstruction phase.

The parameters that optimize acquisitions to obtain the best possible quality data primarily relate to light and should be set according to the lighting conditions of the scene. To facilitate image processing operations, the following should remain fixed throughout the set:

- ISO;
- Aperture;
- Exposure time.

The process of aerial photogrammetry acquisition can be divided into six phases:

1. Survey project;
2. Image acquisition: maximum coverage, constant accuracy, and camera calibration, with care to acquire control points identified as significant points or through markers. To guarantee these conditions, necessary operations should be performed: try to keep the subject of the survey centered in the frame; avoid direct light conditions and prefer diffuse light to prevent direct shadows from darkening parts of the surfaces; use a wide aperture for greater depth of field and to increase image sharpness; ensure at least 70-80% image overlap since the same part of the object should appear in at least three frames taken from different positions; shoot in RAW format;
3. Image pre-processing: in this phase, it is imperative not to crop or resize images, but only to adjust optical aberrations and brightness or chromatic contrast. Crop and exclude from the process any reflective and transparent surfaces that could generate noise, unless polarizing filters have been used;
4. Image processing: the images must be aligned, turning a sparse point cloud into a dense point cloud.

In photogrammetry, specific capture schemes exist depending on the morphology of the subject to be surveyed (e.g., sweeping, radial, etc.). In the case of aerial photogrammetry, in addition to defining the flight plan, it is relevant to determine the distance at which the camera should be positioned relative to the object. This is called *Ground Sampling Distance (GSD)*, which corresponds to the pixel size on the ground, i.e., the resolution and definition that the final numerical model will have.

Data Restitution and Organization – Integrated Survey (T.E.)

The individual point clouds, from *TLS (Terrestrial Laser Scanning)* and aerial photogrammetry, must be merged using targets and/or common known points to ultimately reconstruct the complete image of the surveyed object. Since the Laser Scanner survey is georeferenced, it is possible to measure the coordinates of the chosen points for alignment on the corresponding cloud and insert them into specific control points of the photogrammetric cloud. This process aligns and scales the photogrammetric data, enabling the overlay of the two (Fig.6).

From the resulting point cloud, a series of key pieces of information can be extracted for a participatory reconstruction of the locations. In the post-emergency phase, the geometric survey allows for quantification and provides an image of the damage situation. It also captures a snapshot of the place before the heritage is lost due to subsequent anthropogenic operations, such as demolition and securing. Information related to the material and damage status, linked to the usability of the locations, is obtained from the rapid survey using specific sheets according to the building types. The integration of this information allows for alignment checks, a preliminary assessment of structural conditions, and the initiation of safety and reconstruction procedures.

With the start of the rebuilding process, the collected data can guide design choices and, if desired, enable the virtual reconstruction of the lost heritage, tangibly fixing what is no longer physically present.

D Fact Sheet – Material Data (E.P.)

The key word in a seismic scenario is timeliness: having competent responses on the actual state of conservation of private properties and cultural heritage real estate enables the securing of the sites, in line with the occurrence of further aftershocks. At the same time, the verification of the buildings allows the return of inhabitants and the resumption of economic activities, as well as the quantification of the reconstruction operations.

It is the rapid survey that allows for the quick collection of all the necessary information for the assessment of a post-emergency state. As previously described, the advantages of mass data acquisition through integrated surveying are utilized, complemented by a careful site inspection campaign using technical sheets that have been perfected over the years under the direct coordination of the Department of Civil Protection.

Following the seismic events that affected Italy in 2009, 2014, and 2016, the regulatory framework defined a series of tools for damage inventory and post-event building usability assessments, as well as for preventive purposes.

Data collection activities are coordinated by the Department of Civil Protection, which relies on professionals to compile the following during site inspections:

- Level 1 damage, emergency intervention, and usability sheets for ordinary buildings in the post-seismic emergency (AeDES [1] and similar) (Empler, T. (2020) (Fig.7);
- CarTis sheets[2] for surveying ordinary buildings with the aim of systematically creating a risk exposure mapping on a territorial scale based on the typological/structural characteristics of the buildings (Fig.8).

[1] Dolce, M. et al (edited by) (2014). *Manuale per la compilazione della scheda di 1° livello di rilevamento di danno, pronto intervento e agibilità per gli edifici ordinari nell'emergenza post-sismica (AeDES)*.

[2] Reluis, (edited by) (2014). *Manuale per la compilazione della scheda di 1° livello per la caratterizzazione tipologico-strutturale dei comparti urbani costituiti da edifici ordinari CARTIS 2014*.



Fig. 6 Acquisition procedure from Photogrammetry and integration with TLS in Accumoli, October 2023.

Fig. 7 AeDES form, *Manuale per la compilazione della scheda di 1° livello di rilevamento di danno, pronto intervento e agibilità per gli edifici ordinari nell'emergenza post-sismica (AeDES)*, 2014. Image from Dolce, M. et al (edited by) (2014).

Whether it concerns post-emergency interventions or preventive strategies, the forms are, however, structured exclusively for ordinary buildings, that is, those intended for residential and/or service functions, generally multi-story with masonry or reinforced concrete framed or shear wall structures and limited inter-floor heights. It follows that monumental assets (religious buildings, historical palaces, etc.) or special structures are excluded.

For cultural heritage, the acquisition of relevant information in terms of vulnerability and damage in the event of an earthquake refers to Directive April 23, 2015, which defines the procedures for managing the activities of securing and safeguarding cultural heritage in emergencies caused by natural disasters (I-EC, EM, P-ES, C-ES, A-DC, B-DP, and C-BM forms).

Further research is carried out by Reluis, with the development of databases for mapping the seismic vulnerability of various building types in the national heritage (Empler, 2020).

Regardless of the type of form, on-site, visual, and non-destructive analyses required for the compilation allow for the collection of a set of information that complements the geometric surveys from a typological, material, and diagnostic point of view. The observations to be made are targeted and guided by specific regulatory prescriptions, which currently for the Italian state refer to the 2018 Technical Standards for Construction (NTC 2018) and the corresponding Instructions for applying the Update of the “*Technical Standards for Construction*” (Circolare del 2019).

In particular, the forms focus on the expedient determination of information related to the quality of materials and construction systems: masonry, wood, mortars, reinforced concrete, steel. It should be noted that, in a country where most of the built heritage is historic and based on continuous masonry structural systems, recognizing certain parameters of the state of the art allows the definition and calculation of the Masonry Quality Index (Reluis, 2014), which, depending on how much the parameters are respected, allows the calculation of the mechanical properties of the same.

Fig. 8 Guide for filling out rapid survey forms, *Manual for filling out the 1st level form for the typological-structural characterization of urban areas consisting of ordinary buildings CARTIS 2014*. Image from Reluis (edited by) (2014)

Systematic observations of construction systems aim to define the behavior of individual structural units and the urban complex when subjected to exceptional actions. In masonry structures, for example, it is necessary to identify the piers and floor bands, while in reinforced concrete structures, the position and dimensions of the structural frame and/or the presence of shear walls or earth-retaining walls need to be identified. To assess the possible homogeneous distribution of seismic actions on the structure, it is essential to define the types of floors and roofs, connections between floors, existing structural reinforcement interventions (ties, framing, injections, etc.), or any other element that may influence the behavior of the structures (Fig.10).

Other observations concern the identification of potential collapse mechanisms that may occur depending on the configuration of the structural unit itself, and possibly the interactions between different structural units that will occur in the case of adjoining buildings. The manuals accompanying the proper execution of these rapid surveys provide a reference guide to the possible scenarios that may arise and also allow for the standardization of the information to be collected in order to proceed with simplified structural capacity verification modeling.



Fig. 9 Orthophoto of the Palazzo del Podestà in Accumoli.

3D Modeling (A.P., G.S.)

The BIM Modeler allows the creation of a three-dimensional digital representation enriched with detailed information about each constructive element of the built environment under examination. It is not just a geometric model but an integrated informational platform that gathers multidisciplinary data useful for coordinating the different stakeholders involved in the reconstruction process, such as architects, engineers, builders, and clients (Fig.15 e 16).

The BIM Modeler provides a three-dimensional representation in which every element of the area affected by the earthquake is depicted in 3D with its geometric characteristics such as dimensions, shape, and spatial position. Each component is a parametric object containing information such as material, thickness, and technological characteristics (Fig.10-13).

BIM models are defined based on their LOD (Level of Development), which represents the level of geometric and informational detail of the elements. LOD 100 corresponds to a conceptual model with basic information and simple volumes. LOD 200 is a schematic model with approximate geometries and initial parametric information. LOD 300 represents a detailed model with precise geometries and defined parametric data for each component. LOD 400 is a construction model with information necessary for fabrication and construction. LOD 500 corresponds to the "as-built" model, i.e., the actual model, which is useful for the management and maintenance of the building.

The concept of dimension in BIM refers to adding specific information to the model. 3D represents the three-dimensional geometric model. 4D integrates the time factor, useful for planning the construction phases. 5D adds cost information for the economic estimation of the project. 6D includes sustainability with data related to energy efficiency and environmental impact. 7D focuses on the management and maintenance of the building throughout its lifecycle (Fig.17).

The BIM model offers numerous advantages, including better multidisciplinary coordination since it allows all project stakeholders to work on a shared platform, reducing errors and duplications. Thanks to clash detection, potential conflicts between structural (Fig.14) and systems elements can be automatically identified, improving project quality. BIM ensures transparency and control as every modification is tracked, and all information is always updated in real-time. The ability to simulate the construction process before the actual work begins enables the optimization of time and costs, reducing the risk of delays and unforeseen expenses. Moreover, the "as-built" model allows efficient management of both routine and extraordinary maintenance, improving the planning of future interventions.

UNITÀ STRATIGRAFICA MURARIA Identificativo murario n° 1		Planimetria	Inquadramento in pianta	Inquadramento in prospetto			
Campione murario							
Funzione statica Elevato			Stato di conservazione Mediocre				
Paramento esterno		Paramento interno		Datazione XII Sec.			
Materiale							
PIETRA	Tipo	Colore	Pezzatura	Provenienza	Lavorazione	Finitura	Dimensioni
	Anneria	Giallo/ beige	Conci	-	Squadrato	Aspetti con singoli etruschi	18cm x 13cm 18cm x 14cm
LATERIZIO	Colore	Forma	Origine	Impasto	Finitura	Dimensioni	
MALTA	Colore	Legante	Inerte	Granulometria	Finitura giunto	Consistenza	Dimensioni
	Giallo ocra	Calce	Sabbia	Media	Liscio	Pastosa	0.3 - 0.4 cm
Posa in opera Apparecchio a filari abbastanza regolari caratterizzati da conci di pietra anneria legati da malta.				Modulo			
Note / osservazioni La torre civica risale al XII Sec. ma non si hanno notizie certe di successivi restauri effettuati sulla muratura. Questa, in seguito ai danneggiamenti causati dalle scosse sismiche del 2016, è stata messa in sicurezza con una "inaglia" di legno e cavi metallici che ne compromettono la vista complessiva della muratura. Presso la torre "del Podestà" di Accumoli si osservano invece alcuni conci squadrati in pietra di picconiere sulla faccia esterna, all'interno di campi delimitati da nastri probabilmente rivestiti a scabro. La qualità di tale lavorazione, parzialmente compromessa dall'erosione della pietra, non è tuttavia molto chiara, ma ricorda alcuni nei esecutori attenti a favorire la lettura d'intoracci." (M. De Meo, 2006)							

Fig. 10 Stratigraphic Unit USM1 of the Palazzo del Podestà in Accumoli.

UNITÀ STRATIGRAFICA MURARIA

Identificativo murario n° 2

Campione murario

Planimetria

Inquadramento in pianta

Inquadramento in prospetto

Funzione statica

Elevato

Stato di conservazione

Discreto

Paramento esterno

—

Paramento interno

—

Datazione

XII Sec.

Materiale

	Tipo	Colore	Pezzatura	Provenienza	Lavorazione	Finitura	Dimensioni
PIETRA	Anneria	Giallo/beige	Conci	—	Squadrato	Paramento nudo con tegole rosse	18cm x 13cm 18cm x 14cm
LATERIZIO	Colore	Forma	Origine	Impasto	Finitura	Dimensioni	
MALTA	Colore	Legante	Inerte	Granulometria	Finitura giunto	Consistenza	Dimensioni
	Giallo / grigio	Calce	Sabbia	Fine	Arretrato	Pastosa	0.01 - 0.2 cm

Posa in opera

Apparecchio a filari abbastanza regolari caratterizzati da conci di pietra anneria legati da malta.

Modulo

Note / osservazioni

Il palazzetto del Podestà risale al XII Sec. ma non si hanno notizie certe di successivi restauri effettuati sulla muratura. I giunti sono arretrati, probabilmente perché erosi, oppure per presenza di malta povera (mediante prelievo di campione è possibile valutare la sua natura e le cause dell'arretramento).

Fig. 11 Stratigraphic Unit USM2 of the Palazzo del Podestà in Accumoli.



Fig. 12 Section A-A and B-B of the Church of San Giorgio in Terracina.

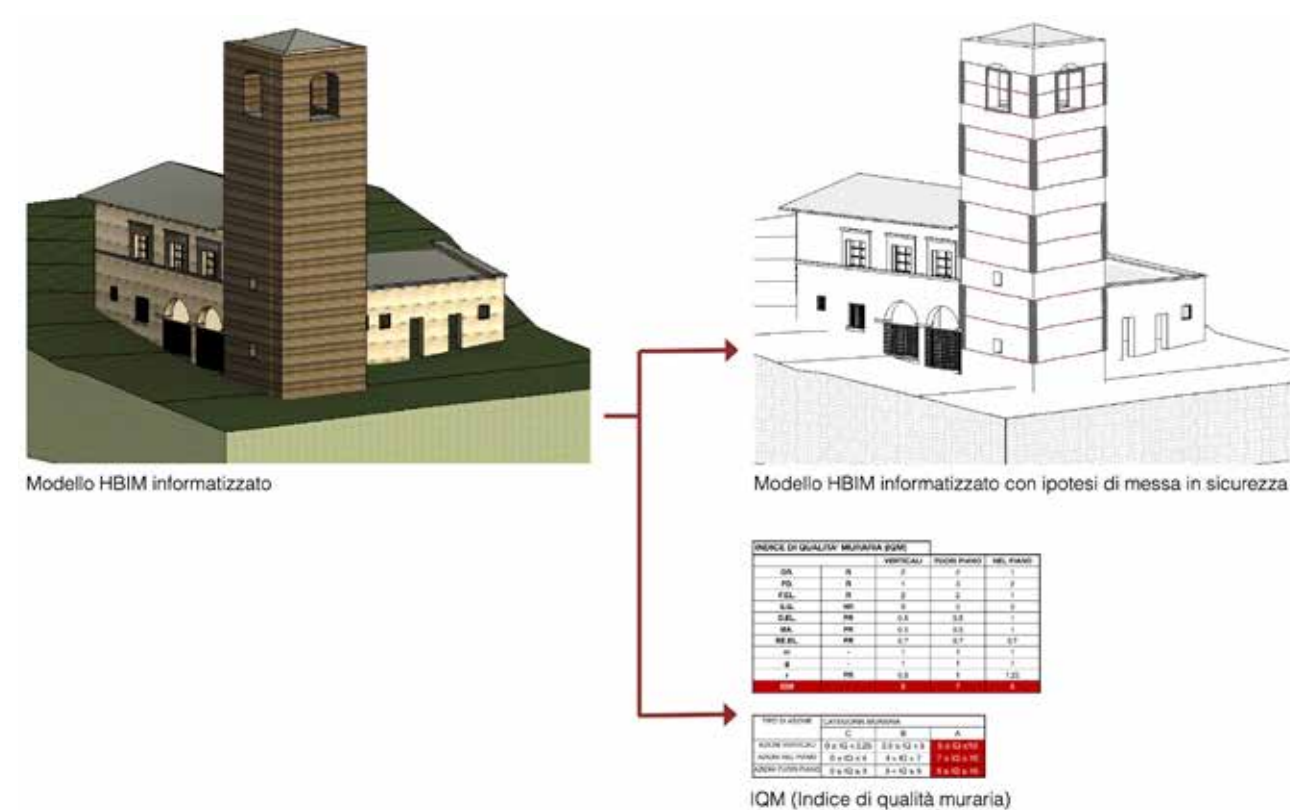


Fig. 14 Parametric informed model with hypotheses for the safety reinforcement of the Palazzo del Podestà in Accumoli.

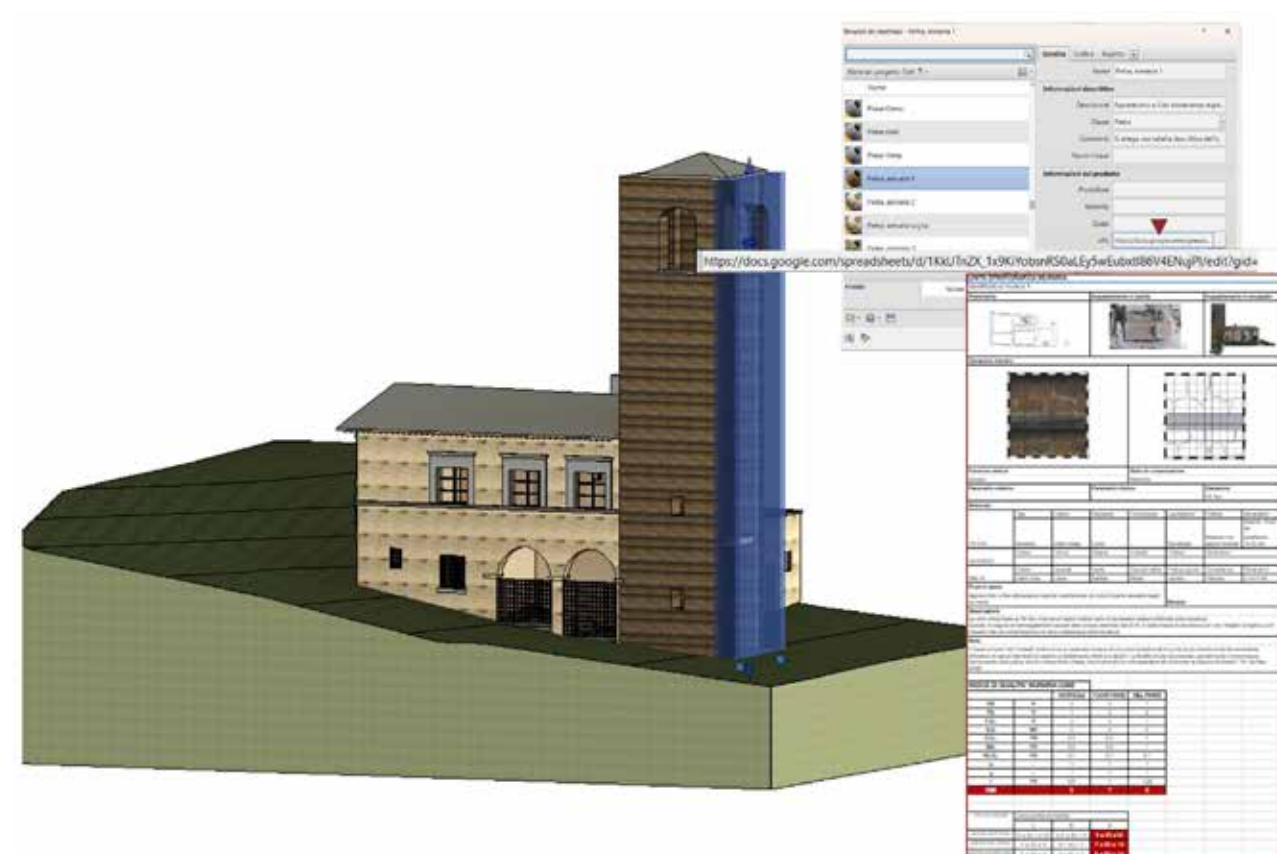


Fig. 13 Parametric informed model of the Palazzo del Podestà in Accumoli.

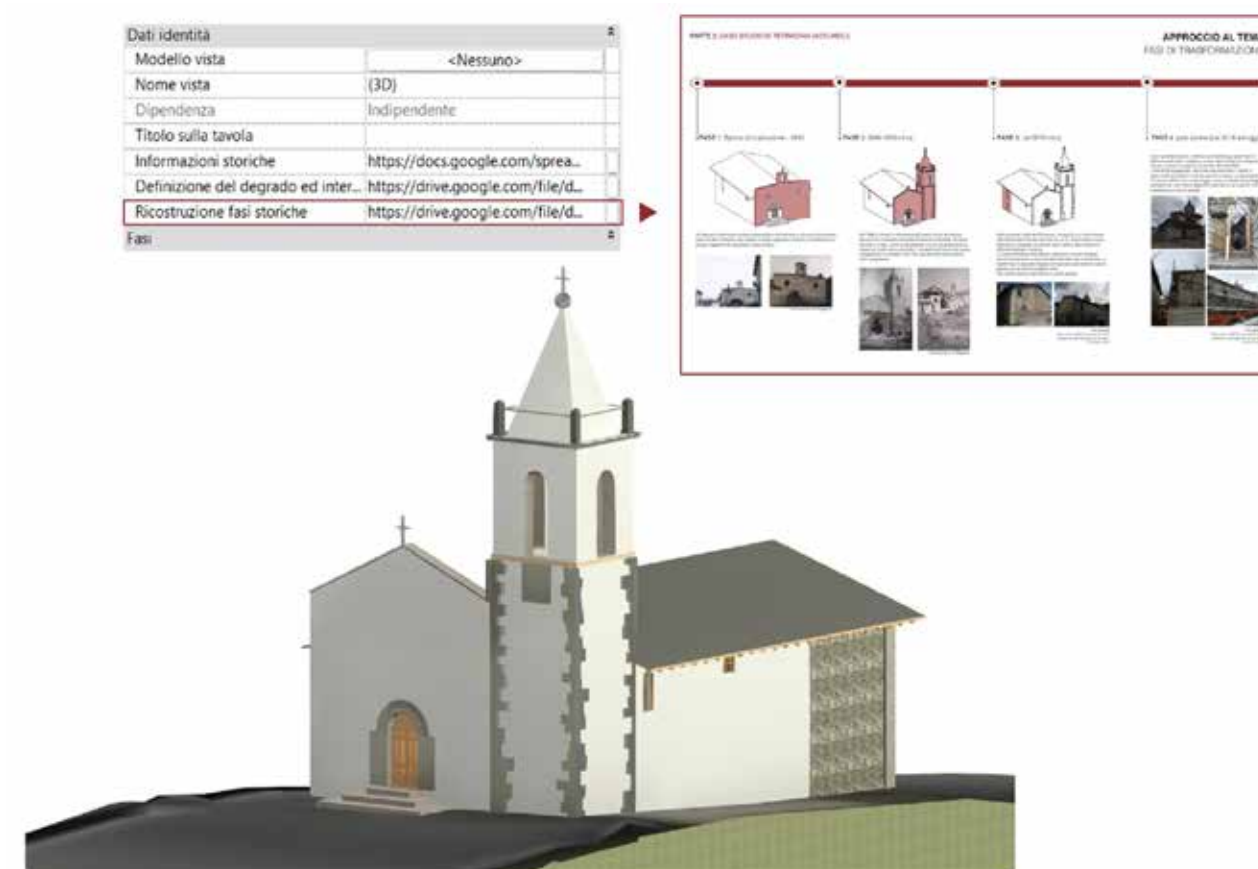


Fig. 15 Parametric informed model, with development of the historical level, of the Church of San Giorgio in Terracina.

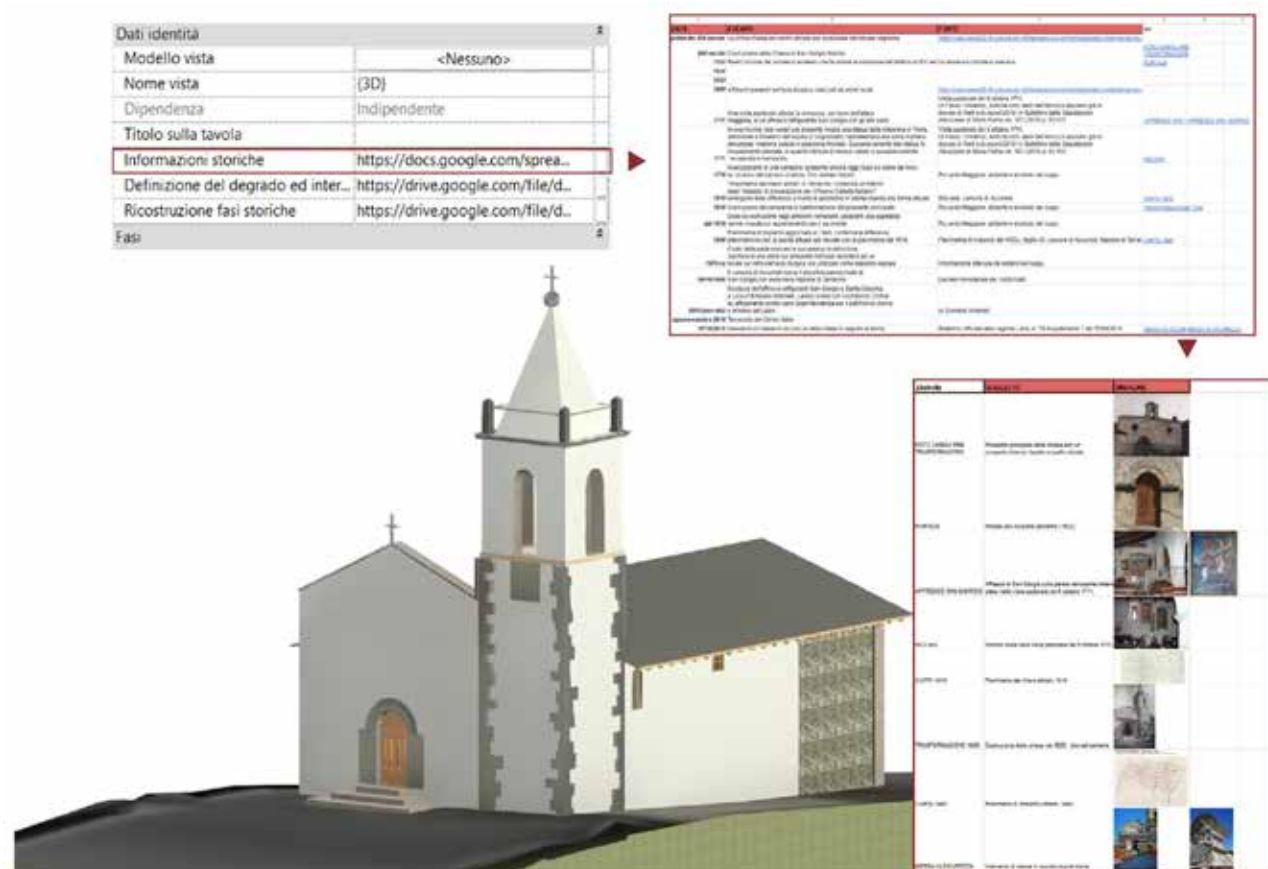


Fig. 16 Parametric informed model of the Church of San Giorgio in Terracino.

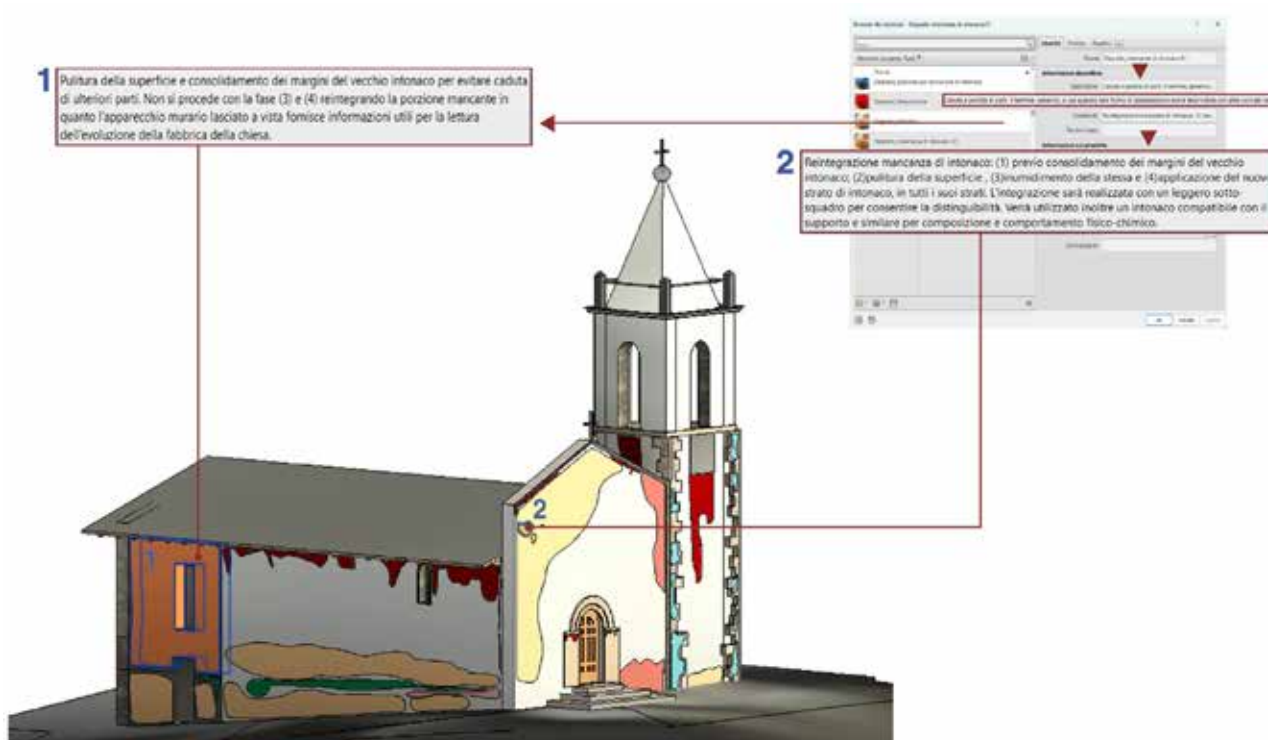


Fig. 17 Parametric informed model with hypotheses for the preservation of the Church of San Giorgio in Terracino

Common Data Environment (T.E.)

A Common Data Environment, also known as CDE, represents a fundamental element in information management. It is a centralized digital platform that collects, organizes, and stores all information acquired during the data collection process, allowing all parties involved—such as designers, engineers, builders, and clients—to access the data in a controlled and coordinated manner.

The primary function of a CDE is to ensure that each project participant works based on the same, always updated, and consistent information. This significantly reduces the risk of errors and misunderstandings that could arise from using different versions of the same document or model. To achieve this, the system provides strict control over data access and modification, through a permission system that defines who can view, modify, or approve the information.

The CDE is based on a process that involves several phases of information management. Initially, each team works in their designated area, called Work in Progress, where preliminary versions of models and documents are developed. After a thorough review, the information is transferred to a shared area, where it is accessible to other teams for interdisciplinary coordination. Once the final version is reached, the data is moved to the published area, from which it can be used during construction or project management. Finally, all historical versions of the documents are securely archived, ensuring traceability of every change.

The use of a Common Data Environment offers numerous benefits, including improved collaboration among the various project stakeholders, reduction of rework and waiting times, secure data management, and the ability to comply with international standards such as ISO 19650, which establishes guidelines for information management in BIM projects. In this way, the CDE becomes not only a technical tool but also a true collaborative working method, crucial for the success of a complex project.

Thanks to the ability to work in real-time on the same information and maintain continuous control over changes, the CDE enables the transformation of information management from a fragmented process to an integrated and transparent one. This approach not only facilitates coordination between different disciplines but also improves the overall efficiency of the project, providing valuable support throughout all its phases, from preliminary design to the maintenance of the completed work. (Fig.18).



Fig. 18 Common Data Environment of the Palazzo del Podestà in Accumoli and the Church of San Giorgio in Terracino.

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MULTIDIMENSIONAL MODEL - EDUCATIONAL AND CREATIVE TOOL FOR RECONSTRUCTION OF URBAN STRUCTURES.

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Abstract

This chapter presents the applied interdisciplinary research projects of multidimensional model of for Accumoli realized at the FAD STU. It presents variable possibilities of use the modern interactive equipment of Mixed reality (MR) in formal and non-formal education. In combination with the identified conserved valuable part of the existing buildings in Accumoli, preserved original equipment and archival plans, it was possible to reconstruct several valuable spaces of former city. This practical result – multidimensional model - allows to educate students and general public about the heritage that does not exist anymore and should not be forgotten. Using original methodology of digital modelling of historical documents in this way allows the viewer to look closer former parts of the city and to experience the former atmosphere. [1] This model showcases the urban structure as it existed before the disaster, serving as an interactive participatory tool for locals and stakeholders to strategize the town's renewal and envision future scenarios.

Objects can be virtually moved, animated and added, which brings gamification to the educational process of architects and visitors. It was confirmed that the result is beneficial also for the education of younger years of secondary school students as well as for the informal continuing education of older architects and seniors within the university of the third age and in the framework focused on the protection of local industrial routes in digital perspective.

The principle of interdisciplinary cooperation is not only a synergistic element in a complex scheme of organised design process, but also a key educational element in the architectural field. Results of the case studies to date show the large accepting by all stakeholders, including participating general public what will have a significant role in further development issues of the local industrial heritage and its neighbourhood. That could bring other new opportunities and that is the crucial success of this approach.

Virtual Urban Walk: The Use of Environmental Memories in Shaping Collective Community Opinions

Virtual Space and Environmental Memories in Participatory Design Processes. A virtual space with an attractive visual representation can also be applied in participatory design processes. This tool is particularly effective in community engagement, especially for collecting memories and shaping collective opinions, thereby fostering active citizen participation in shaping their future environment.

This methodology is inspired by the concept of the **Urban Walk**, [2] which was detailed in previous chapters and is based on a guided walk through the city with predefined stops, where feedback and insights are gathered for subsequent designs and interventions. However, in the context of the **multidimensional model**, the **Urban Walk** is partially transferred into a virtual environment. The aim of this transformation is to enhance the sense of community belonging through VR technologies and haptic interfaces, streamline decision-making processes, and facilitate smoother approval of collective proposals.

This approach contrasts with previously described studies, which focused on tailoring content to specific target groups. Instead, the emphasis here is on the synergistic integration of diverse opinions into a unified community standpoint. The process evolves from individual contributions towards a shared vision, where a retrospective perspective on the past serves as the foundation for shaping the future. This methodology not only **encourages participation** but also enables the creation of a **collective vision** that reflects the community's identity and trajectory.

Within the Erasmus+ project “**Comprehensive Reconstruction of Urban Structures**”, a similar system was applied in the **restoration of the town of Accumoli**, which was devastated by an earthquake in 2016. Accumoli, a small historic town in the Lazio region, Rieti province in central Italy, became the focal point of this

international project, involving eight universities: **Danube University Krems, STUBA, University of Camerino, Sapienza University of Rome, Masaryk University, Czech Technical University, Budapest University of Technology and Economics, and the Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences**. By integrating VR tools and a **physical model with projected virtual layers**, a participatory design process was conducted, leading to the development of a **shared proposal** for the town's gradual reconstruction over time.

The Principle of Comprehensive Participatory Reconstruction of Accumoli

An Earthquake with a Magnitude of 6.2 and Its Impact on Accumoli. An earthquake with a magnitude of 6.2 on the moment magnitude scale struck central Italy on August 24, 2016, at 03:36 AM. Its epicenter was located near Accumoli, at a depth of 4 kilometers, approximately 75 kilometers southeast of Perugia and 45 kilometers north of L'Aquila. As of November 15, 2016, 299 casualties had been confirmed. (Fig. 1)

The case study focused on addressing the challenging task of restoring and reconstructing a destroyed and largely abandoned town (Fig. 2), playing a key role in shaping the opinions of the local community and facilitating communication with the regional self-government unit. The project was carried out in **three phases**: the **first workshop in Accumoli, studio work at the Faculty of Architecture and Design, STU**, and the **second workshop in Accumoli**.

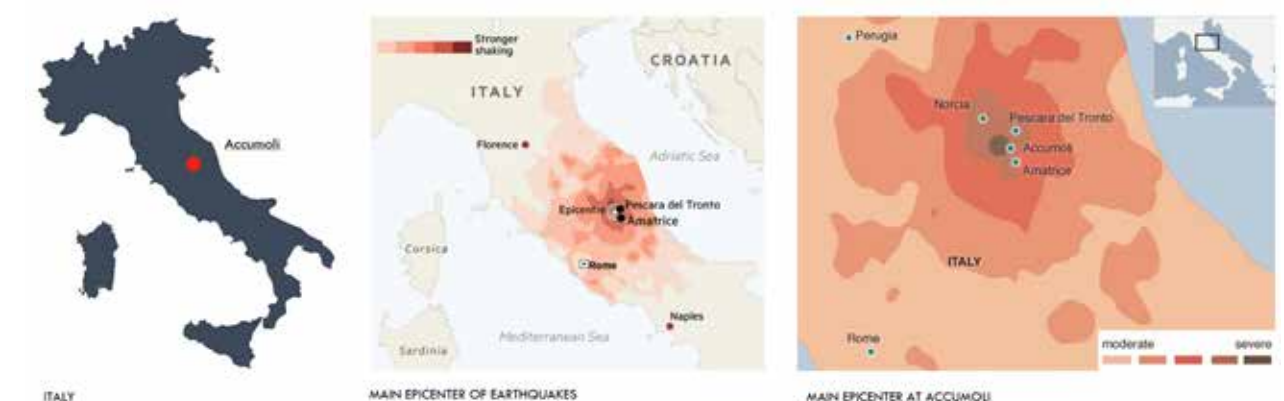


Fig. 1 Common Data Environment del Palazzo del Podestà ad Accumoli e della Chiesa di San Giorgio a Terracina.



Fig. 2 Accumoli before and after the earthquake. Source: Google Maps, V. Mitrová, V. Trecáková, Data[LAB].

First Workshop – Understanding the Environment and Collecting Input Materials

The first workshop took place from September 18 to 23, 2023, in a school in Accumoli, the first newly constructed building in the area since the earthquake. The goal of the workshop was to gain a deeper understanding of the environment of Accumoli and its surrounding areas, including neighboring settlements that were also affected by the earthquake. These settlements included the small town of Terracino, the village of San Giovanni, and the city of L'Aquila. All of these settlements are located in the mountainous Apennine region, characterized by challenging accessibility.

Accumoli and San Giovanni were completely destroyed by the earthquake and remain in ruins to this day. Although Terracino suffered only minor damage, its buildings were deemed structurally unsafe and dangerous, leading to their abandonment. These settlements have been designated as red zones, where access is prohibited (Fig. 3). In Accumoli and Terracino, original residents continue to live in temporary housing constructed after the earthquake. In contrast, the village of San Giovanni is entirely abandoned.



Fig. 3 Ruins of houses and the town hall in the red zone of Accumoli. Source: V. Mitrová, V. Trecáková, Data[LAB].

In contrast to the aforementioned locations, the city of L'Aquila has recovered the most effectively from the earthquake's aftermath. Several damaged buildings have been repaired, but the city still contains areas that were completely destroyed, including the Basilica of Santa Maria Paganica.

During visits to the various municipalities, 360° photographic documentation of the current state was created using a 360° camera. Based on this documentation, virtual tours of these locations were developed. These tours are available online and were enriched during the workshop with 360° photographs of the pre-earthquake condition, obtained from Google Street View. Additionally, a digital 3D model of Accumoli was created during the workshop, based on materials provided by local residents and photogrammetry data supplied by Sapienza University of Rome.

The created visual material was utilized for communication with local residents. Interestingly, the residents were unaware of the photographs of their town available on Google Street View. The students provided them with an opportunity to look into the past and reminisce about their original homes, which opened the door to discussing specific issues hindering the town's reconstruction. The students recorded their responses.

Most residents stated that many people had moved to Rome, approximately 150 kilometers away, or relocated closer to functioning infrastructure after the earthquake. The younger generation sees limited job opportunities in the area. Damaged houses are old and lack the necessary comfort, with repairs being financially demanding.

As a result, Terracino and Accumoli remain home primarily to the older generation, who are emotionally attached to their environment. Seven years have passed since the 2016 earthquake, yet the town's reconstruction has made little progress, apart from the gradual repair of surrounding roads.



Fig. 4 360° panorama showing the overlay of the pre-earthquake condition with the current state. Source: Authors

This stagnation is particularly regrettable, given that Accumoli's history dates back to antiquity, when it was part of the Sabine territory. During the Middle Ages, it was part of the Papal States and played an important defensive role due to its strategic location on the border between the Lazio and Abruzzo regions. Accumoli, Terracino, and San Giovanni are situated in a picturesque mountainous landscape known for livestock farming and dairy production traditions. The surrounding area is rich in hiking trails, contributing to the development of agritourism. Moreover, Accumoli's destroyed historical center offers potential for archaeological research.

The next steps aimed to focus on these local environmental values and incorporate them into the initial proposals for the gradual restoration of Accumoli and its surroundings. These proposals were presented to the town's residents at the conclusion of the workshop. Based on further communication with local inhabitants, a solution inspired by the restoration of Banská Štiavnica was devised. This solution involves regular workshops featuring multiple universities and artists, focusing on the restoration of the historical center and its revitalization.

According to the proposed plan, the first buildings to be restored should include facilities for producing local traditional products and a small hotel. Together with the school, envisioned as the center for workshops, these new interventions aim to attract tourists to this picturesque area and create new job opportunities. The subsequent phase would focus on the restoration of local residents' homes.

Development Strategy: Placemaking

A similar strategy for urban development, known as placemaking, has been effectively applied to the revitalization of underutilized or neglected urban areas. This strategy involves renting such spaces to artists and creative professionals, providing them with opportunities to create and showcase their works, thereby enriching the environment with new cultural values. This approach not only contributes to the revitalization and reactivation of the area but also introduces new functions that are attractive and beneficial to the local community.

The implementation of placemaking includes the creation of cultural and social hubs that foster local development. Artists and creative entrepreneurs settling in these areas often initiate new activities, events, and business ventures that increase foot traffic and interest in the locality.

This approach results in not only the aesthetic and functional improvement of the environment but also promotes social interaction and communal identity.

Additionally, this model contributes to the creation of economic opportunities and new jobs, which are crucial for the sustainable development of urban areas. As a result of this revitalization, the attractiveness of the area increases, strengthening its ability to attract new residents and investments.

However, over time, the development of such locations may begin to work against the very community of artists that initially contributed to their appeal. As land prices rise and more affluent residents move in, artists may be forced to relocate. This process, known as gentrification, can be illustrated by the Concrete Playground project in the Old Port of Ghent. The local artistic style became so appealing that the area became a target for development activities.

Another example is the transformation of the post-industrial block of the Old Thread Factory in Bratislava, which was converted into a cultural center between 2007 and 2012. In 2015, the building was sold to new developers, who later reconstructed it as part of the Zwirn project. This case demonstrates how an industrial site can be revitalized for cultural purposes, but also how it can be replaced with new, often more commercial uses, altering the character of the location.

Unlike Accumoli, the mentioned examples took place in larger cities. However, the placemaking process could have a positive impact on tourism in Accumoli as well. The negative effects of gentrification might only manifest in such a remote location if an unexpected surge in the area's popularity occurs in the future. It will then be the responsibility of local residents and authorities to regulate this process.

These ideas and collected data served as new inputs for the Data[LAB] studio design proposals for the multidimensional model.

The Creation Process: Studio Work at the Faculty of Architecture and Design

The assignment for Accumoli was addressed in the studio during the winter semester of 2023. The project's objective was to create a realistic and optimistic scenario for the restoration of the small town and its surroundings by 2050, based on the collected materials. A key aspect of this project was the connection with the surrounding environment, as Accumoli is not just the town itself but also its natural surroundings, which could play a significant role in the restoration process.

The scenario aimed to encourage local residents, help them advocate for new plans before the municipal government and local stakeholders, and secure financial support for the reconstruction. Without a gradual restoration, the town faces the risk of complete abandonment.

During the semester, based on the input data, students from the Data[LAB] studio created an urban model of Accumoli and its surroundings, measuring 1500 x 750 mm. The model allowed for the projection of various information layers and spatial analyses. Working with the model enabled the identification of key valuable locations in the town and the design of essential infrastructure. These key points, connected by a main route through the area and linked to nearby hiking trails and roads, are intended to act as catalysts for placemaking and the gradual reconstruction of the entire town.

Many of the original residents relocated closer to the main road in the Fonte del Campo valley. This new settlement is envisioned to become the gateway to the restored town of Accumoli. The historical center of Accumoli, situated on a hill, will be connected to the valley by a cable car and a route designed for pedestrians and cyclists. The cable car station in the valley will include a small café, an information center, and a bike rental facility. (Fig. 5)

The cable car, pedestrian route, and cycling trail converge on the hill where the new main square of the town is located, previously used as a parking lot. This square could host markets with local products and summer concerts, while offering a beautiful view of the valley. In close proximity to the square is the restored church.

The parcels of destroyed buildings remain in private ownership and, in the initial phase, become the center of placemaking through various local activities, such as animal husbandry and gardening.

Some ruins are partially restored and repurposed as simple pavilions and shelters for the production of traditional artisanal goods. These reconstructions gradually restore parts of the destroyed buildings, while over time, new houses may be built on some parcels, maintaining the scale of the original structures of the town. (Fig. 6)

The **route connecting the individual points** follows the ridge of the hill and passes by the preserved town hall, which now houses a **restaurant and guesthouse**. This part of the town serves as a **hub for artists**, offering them space to create and showcase their works, with their activities closely tied to the **local natural environment**. (Fig. 6)

Another **key point along the route** is the **school**, which, after being expanded to include a kitchen, dining hall, and adjacent temporary housing, becomes a **center for workshops** organized by several Italian universities. Similar to the satellite campuses of the **Faculty of Architecture and Design** and the **Academy of Fine Arts and Design in Banská Štiavnica**, the school provides a space for various academic and artistic activities.

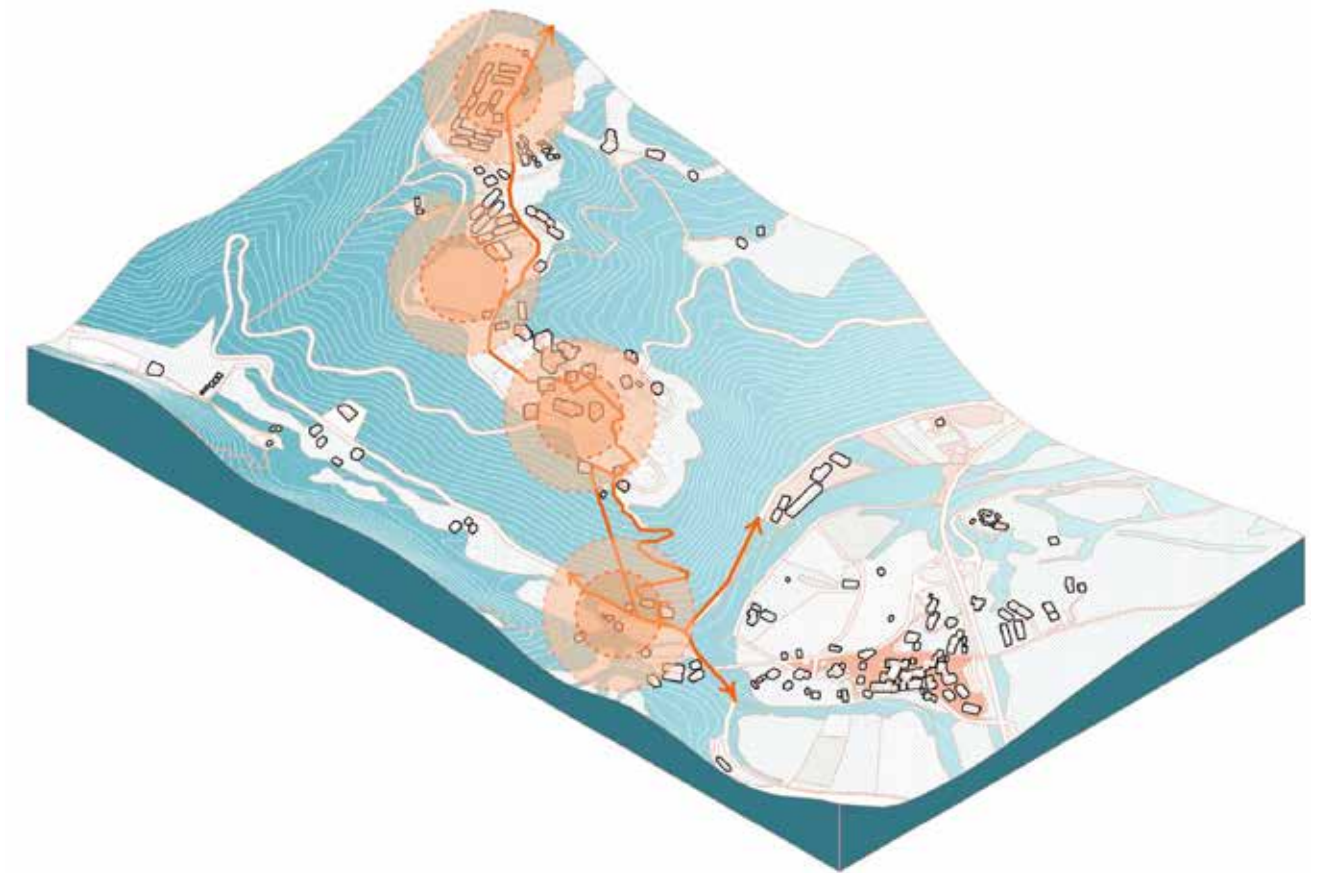


Fig. 5 Identified activation sites connected by a main route to surrounding infrastructure and nearby hiking trails. Source: V. Mitrová, V. Trečáková, Data[LAB]

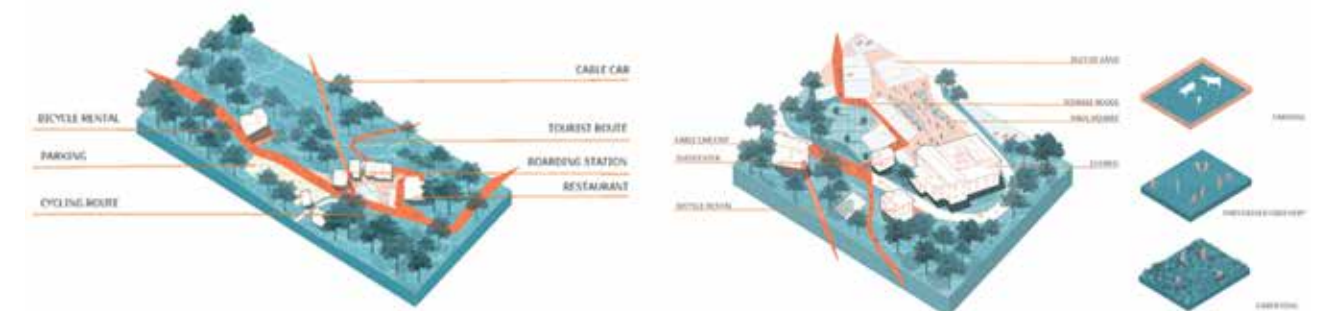


Fig. 6 The first placemaking point – the cable car station in the valley, The second placemaking point – restoration of the church and surrounding plots. Source: V. Mitrová, V. Trečáková, Data[LAB]

Annual workshops focusing on archaeological research, the restoration of historic buildings, or artistic endeavors could be held here. The outcomes of these workshops could then be exhibited in the square within the historic part of the town. (Fig. 7)

Local artists, craftsmen, and students would thus contribute to enhancing the **attractiveness of the location** while gradually restoring the buildings in the historic center. Over time, the school could evolve into a **small campus**, offering **workshops, playgrounds, and a library**, thereby fulfilling additional necessary functions and fostering **community life**.

The final point along the proposed route is the temporary housing constructed after the earthquake. Originally serving as a provisional base for those rebuilding their homes in the center, this area will gradually be transformed. Over time, the historic center of the town will once again become a vibrant place, home to returning original residents as well as new settlers.

The temporary housing will thus be converted into permanent residences for those who, due to the catastrophe and trauma, are unable to return to the center. This peaceful location near the mountains will become a home primarily for seniors. Over time, it will be adapted to offer its residents adequate privacy and comfort, creating a space that meets their long-term needs.

The proposed design was projected onto the physical model, enabling the visualization of the activation points, the main connections across the area, and the gradual process of placemaking. The model was enhanced with VR [4], which displayed the original state prior to the 2016 earthquake, the current state in 2023, and the planned restored state in 2030. (Fig. 8)

This model showcases the urban structure as it existed before the disaster, serving as an interactive participatory tool for locals and stakeholders to strategize the town's renewal and envision future scenarios. With variable physical representations of the town centre in both its present and pre-disaster states, the model offers a tangible platform for discussion and decision-making. As the town is situated in the highlands, the LED screen backlighting is impractical, strategies for town renewal are instead projected interactively onto the model. (Fig. 9)



Fig. 7 The second placemaking point – partial restoration of the town hall and adjacent buildings. Source: V. Mitrová, V. Trecáková, Data[LAB]

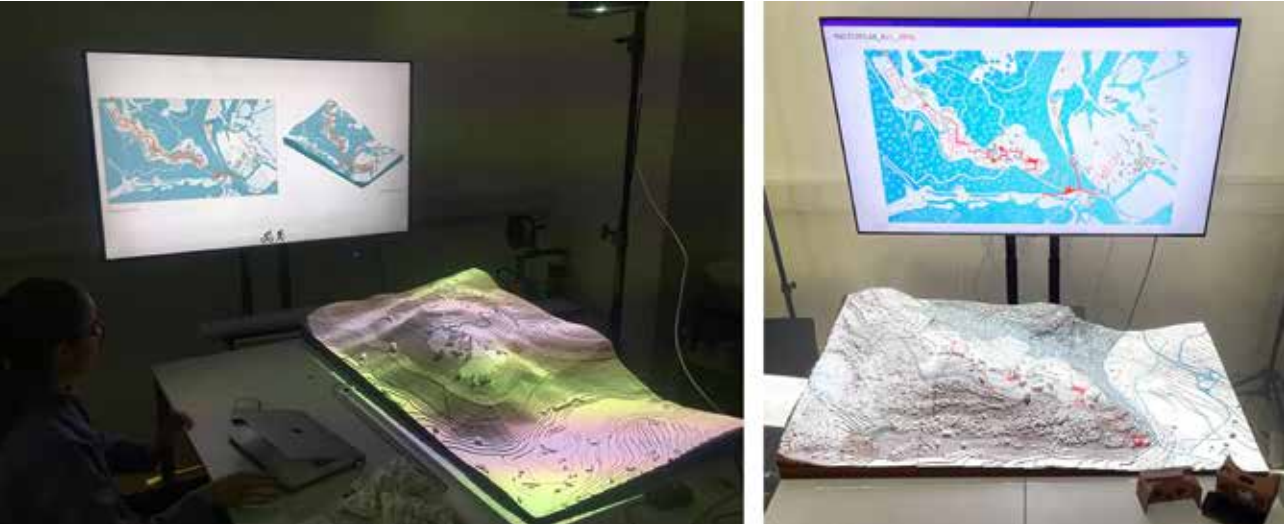


Fig. 8 Visualization of the gradual restoration of the town projected onto the physical model. Source: V. Mitrová, V. Trecáková, Data[LAB]. Photograph by: V. Hain

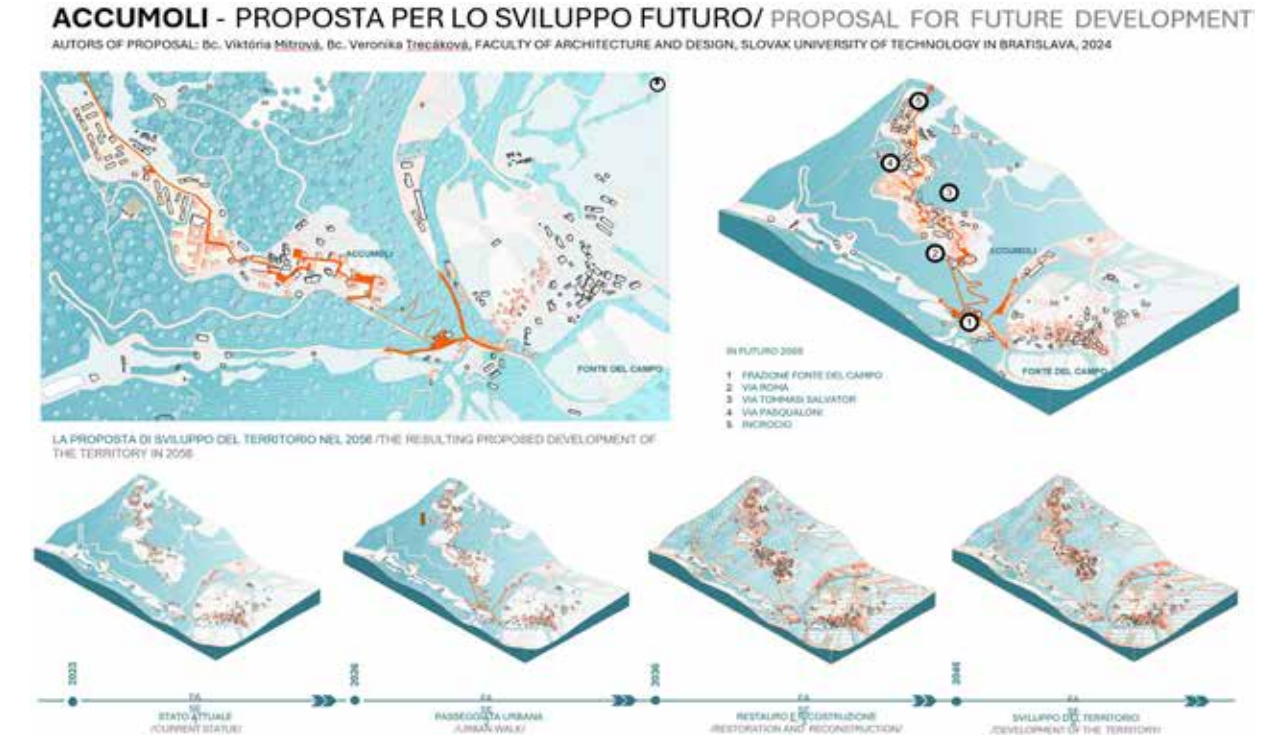


Fig. 9 - Urban multidimensional model of Accumoli (Urban design for the conversion of city after the earthquake) on which it is possible to project from above with included virtual layers and markers for augmented and virtual reality. (Source: Author archive, FAD STU, Data[LAB], 2024)

Second Workshop – Discussion and Engaging Local Residents On-Site

The second workshop in Accumoli took place from May 27 to June 1. Its primary goal was to present the town's reconstruction plan to local residents and stakeholders, gather their opinions and feedback, and create a new informational layer that illustrates both the past and the envisioned future state of the area.

The workshop included the creation of materials for participatory design, such as a detailed map of the area where residents could record their comments and suggestions. Another component of the workshop was the installation of informational boards at selected sites designated as future activation zones. These boards provided visitors with an overview of the potential state of the locality by 2030, enabling residents to visualize and evaluate the planned changes and their impact on the local community.



Fig. 10 - Maps for collecting feedback from local residents and installed informational boards with QR codes linking to panoramas of the town's past, present, and future states. Source: ComPaRe project partners. Photographers: M. Uhrík, Authors

Virtual Urban Walk Utilizing the Model

The proposal was presented through a method similar to an Urban Walk, where local residents were introduced to future scenarios for the town's restoration at various activation points. The use of VR technologies allowed participants to compare the current state with the proposed changes and gain a deeper understanding of the suggested solutions. Additionally, VR facilitated the collection of feedback from participants. [5]

The presentation was complemented by a physical model, onto which the activation points were projected. This combination encouraged open discussions and the exchange of ideas among the participants.

Local residents and other stakeholders regarded the proposal as realistic and received it very positively.

They were particularly impressed by the planned restoration of the church and the town hall, which are considered crucial for the future revitalization of the historic town center. Feedback from residents was minimal, focusing mainly on the placement and functional use of specific buildings and parcels.

The results of this participatory process were subsequently incorporated into the physical model using virtual informational layers, making the model a significant tool for further communication and planning.

The principle of interdisciplinary cooperation is not only a synergistic element in a complex scheme of organised design process, but also a key educational element in the architectural field. It is possible to embed interactive virtual parts in traditional interpretation with the possibility to control the animations by focusing the view on specific objects. By such kind of mixed media presentation and multi-sensorial experience is possible to receive experience with high immersion. The combined methodological framework and Integrated *Approach to Curriculum Design* [5] in multidimensional model is an instrument of deeper insights into the topic, potential solutions and side effects facing students, educators, resource managers and other stakeholders.

All project outputs, including the VR simulation and the physical model, were left with the town of Accumoli to serve as a support tool for communication with provincial authorities, securing funding, and further detailed restoration planning.



Fig. 11 An example of interdisciplinary cooperation combined with onsite research and Urban Walk. (Source: Authos, Data[LAB], 2024)

Conclusion

The combination of **VR and the physical model** offers numerous benefits across various aspects of education and decision-making processes. Firstly, it facilitates the **effective transfer of information** and raises awareness about the future development of the area. By reducing informational overload, it allows for a clearer identification of issues and goals. Additionally, the model serves as a tool for **active learning**, benefiting both stakeholders and the general public. Its immersive nature fosters a deeper understanding of the challenges, leading to the generation of **innovative ideas**. [6]

Moreover, the model enhances **teamwork** and increases **participant motivation** in the participatory process, resulting in a higher likelihood of achieving **objective and positive outcomes**. In the case study of Accumoli, the final proposal was **unanimously accepted by all stakeholders**, including the public, which could play a significant role in the **future development of the region's historical heritage** and its surroundings.

Acknowledgement

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URBAN WALKS AS A TOOL TO INDUCE PARTICIPATION IN THE RECONSTRUCTION PROCESS

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Abstract

Participatory reconstruction is essential in heritage areas, especially after disasters. Locals, accustomed to a stable environment, face overwhelming changes when their built surroundings are destroyed. Urban walks can bridge the gap between professionals and the community, offering a platform for knowledge transfer and shared decision-making. Walks are effective for engaging locals in the reconstruction process by revealing the hidden layers of their urban environment and the reasons behind professional choices. They provide an opportunity for citizens to voice concerns and for professionals to explain complex preservation, technological, and economic factors.

These walks, often led by passionate guides, allow participants to connect with their heritage while learning from experts. By incorporating local stories and professional insights, urban walks foster dialogue and provide a platform for community participation in decisions about reconstruction. This method is especially effective in complex, post-disaster contexts, ensuring that reconstruction efforts reflect shared values and priorities, and maintaining the integrity of historical and cultural identity.

Goals - Participation of locals and professionals for a common understanding of heritage values

There is a need for participatory reconstruction processes in heritage areas, mainly because reconstructions after disasters are outside of the common experiences of urban development that societies have, and the values at stake and techniques to be used are at the highest - professional levels of understanding, therefore too much knowledge, too much complexity must be handled in unusually short timespans in the life of settlements. Society have to process too much loss, and too much data on reconstruction, values and technologies. Locals living in such heritage areas destroyed by disasters face the largest overload of new information: as inhabitants of a historic urban structure they have been used to be surrounded by a built environment that have been there since ages, and was never meant to be significantly altered. At once most of that environment disappeared, and the tension between old walls and new resistant technologies, between old habits and new lifestyles, between the eternity of heritage and the instant adaptation needs post-disaster became evident. How to process that and how to understand the professional decisions on what to reconstruct and how, and what to leave behind forever? Many times disasters mean a new possibility for professionals to rethink the urban environment, the heritage values and construction technologies, but locals will not be ready to follow the new ideas, will not value the new archeological discoveries under the rubbles of their own houses and will not understand why is the reconstruction process going in certain directions.

Local societies cannot be sent back to school to learn about the complex professional reasons behind heritage preservation decisions structural novelties and economic calculations made for the reconstruction process. However, locals must learn about such decisions and must have live connections with professionals guiding the reconstruction (Grcheva & Oktay Vehbi, 2021; Hribar et al., 2015), if not, they will become disconnected from the environments they supposed to live in after the works. Instead of complex knowledge transfer and pointless auditions in some meeting rooms there is a method to connect professionals, their reasonings and locals and their insights right on the site to be reconstructed: urban walks.

Methods - Using urban walks to get user data and to build common understanding and goals

Urban walks are highly effective and appropriate tools for knowledge transfer and participation that involve walking, observing, and sharing knowledge at various levels (Husar et al., 2020). Recognized by UN-Habitat as a successful planning method for shaping the New Urban Agenda, urban walks employ a

“community-based approach” to urban development. It is a dynamic tool for raising awareness, sharing objectives, and involving citizens in city participation and planning. Beyond the organization and support of experts and technicians, the community’s involvement, questions, doubts, and proposals during this “on the move experience” are essential. Jane Jacobs was using this method since the 1960’s to express her worries about the proposed policies and obtain people’s opinions and preferences about the places they live in.

The method of urban walks builds on the multi-sensorial experience participants have while walking, observing, sensing and at the same time understanding through experts guidance their environment. This method is particularly effective when hidden stories and/or specialized professional reasons lie behind elements of the built environment that usually go unnoticed, but contribute to the identity of the place. The method helps participants to connect with the values that shaped that environment, and it can help to connect with the professional reasons behind the current state of the art, or future projects regarding that environment.

Urban walks are mostly led by well-trained amateur guides, enthusiasts themselves of the place they present. However, more and more projects of schools use this method to make a knowledge transfer directly between specialized professionals and the general public. In fact the most complex historical, structural or urbanistic principles can become understandable if explained through real examples moving between good and bad practices, different situations and hidden details to be revealed on-site. The experience of guiding an urban walk can be substantial also to a professional usually working in a specialized field with little connection with the public. In fact such professionals learn on-site while talking to locals how the public must be addressed with more down-to-earth explanations and what are their reactions, in the best cases their reflections on-site. Good walks induce discussion on-site, and such gives live feedback to professionals about their field and its applications to a real building environment (Husar et al., 2020)

Civil or professional initiatives with specific aims to involve citizens in decision making for urban environments use urban walks and often they combine this method with other methods of participation. Surveys often accompany urban walks, but even more effective are the live discussions on-site, or the surveying of participants through gamification during the walks. Advanced sensor technologies allow the measurement of the attention or emotion of participants with Eye-Movement, Heart Rate Variability or Galvanic Skin Response sensors, however, such methods during walks are more often used for scientific research, not for participation.

The purposes to use urban walks in heritage areas facing reconstruction after severe disasters are multiple, and the method of the walks make such tools ideal in these cases, as there is no better way to create a common platform between locals and professionals in complex situations (Cantillon, 2020; Huss, 2023, 2024). Urban walks in heritage areas after disasters are able to create a platform for knowledge sharing and discussion:

- Locals can express their priorities and main concerns in the reconstruction process, while they can reveal the values and hidden heritage dimensions of the destroyed environment
- Professionals can explain the complex factors behind preservation, deconstruction, new technologies and new forms that might (and will) emerge during the reconstruction, and they can facilitate decision making.

Tools - Creation of urban walks to reveal the multiple cultural layers of a city

In the process of the reconstruction of an urban area architects, planners and heritage specialists can rely on the method of urban walks in order to involve the population or other interest groups in the process itself. The main goal in these cases is to convey complex professional arguments regarding the reconstruction process in the most comprehensive ways, helped by the on-site perception of built and natural elements, and by real dialogue with the involved audience. The outcome can be either to inform the participants or to involve them in the reconstruction process, but also to empower them to make solid arguments themselves regarding their own environment (Husar et al., 2020). The difficulties come from the complexity of the urban environment, from the multiple cultural layers that often seem to contradict each other and it is often not obvious which of such layers gains priority in the reconstruction process (Cantillon, 2020; Huss, 2023). How to prepare such walks?

1. DEFINE THE GOALS: INFORM OR INVOLVE

The most important task is to define the purpose of the walk. Urban Walks are created in order to make accessible the information about a specific environment to participants, but when professionals use walks as

a participatory tool for the reconstruction process of an urban environment, it is important to define whether the goal is only to INFORM the public of the values and processes on the site, or to INVOLVE them in the reconstruction process. In order to achieve involvement the process must be designed to have input from the public, not just output towards them. This means that the goals and right questions must be clarified right at the beginning. The following questions must be answered:

- Who is the audience? What is the purpose of the walk with that audience?
- What are the professional facts/arguments that architects/planners/heritage specialists hold which should be transferred to the public for understanding?
- What are the key issues where the support of the public is essential and the walk should help to gain that?
- What are the main questions that the public/participants should answer in order to move forward undecided issues in the reconstruction process?

2. MAP THE INTANGIBLE: SOCIAL, HISTORICAL AND HIDDEN RESOURCES

Architects and other professionals working on walking tours probably have a lot of specialized knowledge and some general knowledge of the place itself. But most of the times they are not locals, and themselves visited the site only a few times and in a purposeful way. In order to lead an urban walk in a credible way the guides must “become” locals to some extent. This means they have to know the physical and social-historical environment very well, not only the route they will take, but also its wider areas. The first step must be to map the intangible, even before mapping the place itself physically. The history, the main socio-economical facts, the geography, and the stories available of the given urban area must be studied and at hand for the walks. History is very important, as every physical element in the urban area is tied to one or many historical periods, therefore the guide, even if its profession is not related to history must be aware of it. In reconstruction areas after disasters the facts and stories of the disaster itself must be studied deeply, as well as all variants that emerged of the possible reconstruction methods after. Hidden stories and resources must be collected from local sources. The best sources are local cultural institutions, NGOs, amateur local historians, and locals themselves. It is easier to work in an environment where such stakeholders already mapped (and published) many stories and facts about the urban environment, but participatory methods to gain such data exist, like the TOPOTHEQUE mapping platform or others. Such methods are many, therefore it is not the quest of this paper to present them: any methodology or help can be used in order to map the local stories and intangible values of the place.

3. MAP THE PHYSICAL ENVIRONMENT

The physical exploration of the site is essential only when data of the history, main facts, geography and social and intangible givens of the place are properly mapped, when the individual buildings and places have been processed with all data. Explorative walks should be concluded in the area by the tour guide in order to connect the stories and facts with the physical reality of the urban environment in his own interpretation. This



Fig. 1 Students mapping the physical environment of Accumoli during the ComPaRe workshop in September 2023.

is very important after a disaster that ruined the built environment, as the guide has to know how the given places looked like before the disaster and how they are now, giving time to process the changes in its own mind before preparing to make an urban walk that includes that site. It is also important to walking tour guides to map the environment with an eye to the walkability options, see which routes are easy to walk, which have obstacles for some (like elderly or disabled people), which de-routes the group could take if an unexpected obstacle will appear, and where to stop for explanation taking into consideration the extent of the group, visibility and audibility, shade in case of summer days. Therefore tour guides as a first step have to map the wider area by walking through every possible path, observing all spaces for the aspects listed above, and having a map of the places of interests, all items that will be included in the stories, all amenities.

4. CATEGORIZE AND SELECT THE TOPICS, THE HERITAGE AND THE MESSAGES TO CONVEY

An urban walk cannot tell the complete story of an urban area. Based on the goals and target groups defined in the first point the guide must categorize on a map all knowledge collected in the desk research (2) and on the physical exploration (3) and select the categories most useful in order to convey the main messages of the walk. The main message can be the how and why of the reconstruction process, explaining why some elements are important to reconstruct and others not for example, but when the goal of the walk is to INVOLVE the participants into the reconstruction process this becomes more complex, as stories and facts that give a strong fundament to some questions to pose to the public must be selected, and the questions to ask must be based on these and these must be to-the-point. Therefore a map which categorizes all data collected and shows only those of primary and secondary importance in respect to the topics must be created, every building and site must have a data-point with photos before and after, with basic facts, and most importantly with local stories associated to these. The data map should leave space open for new stories that the participants of the walk will reveal associated to a given place that the walk will touch.

5. CREATE A ROUTE

From the database mapped (4) a coherent walkable tour must be created. This tour will not be able to comprehend all points of interest for the topic, therefore a second selection is made in this step. The main selection criteria is the route itself, its walkability, duration, good starting and ending points. A line will be drawn on the map with points to stop, explain and discuss. The walk should be no longer than 2 hours if taken by foot! The line should not only take into consideration the physical facts (3), what comes most easily after another point: in fact this line is the story telling line of the walking tour, it should be constructed in a way to have an introduction, beginning, stories built one upon each other, and a proper conclusion and ending. The route must be walkable though and not too hard to follow, therefore the line should be a relatively simple form, without self-intersections. Points to stop should be constructed in a way that the group could comfortably gather around the guide, but also see the objects to be presented. Amenities such as drinking or sitting down should be considered at points. Routes shouldn't be too steep, and never be dangerous! Especially in places under or before reconstruction after a disaster the security of the walk and stops becomes a top priority!

6. CREATE MATERIALS TO SHOW DURING THE WALK

Multimedia materials of printed materials should complement the stops and presentations of the walk. It is somehow obvious that images from historical and pre-disaster states of the built environment should be shown to participants while they are at the site in case of walks to urban areas in the reconstruction process after disasters. But also other visual material is beneficial, like personal photos of past users, plans and technical drawings, art related to the site, etc. Digital technology helps, the basics it to bring a large tablet and show the materials on that, but advanced technologies permit to have reconstructed or pre-disaster VR or AR material available, such technology used on-site elevates greatly the interest in the walk and the efficiency of knowledge transfer. However, printed photos, maps, plans are also great, these should be prepared in a water resistant case, easy to show around. A good method is to print a map of the tour with all graphical, visual and also textual information, distributed to all participants. Even if most data is on these maps, the personal guidance is not compromised, especially in interactive walks where the main purpose is to gain new data from participants, and to seek for comments, observations and definitive answers regarding certain pre-defined reconstruction processes. For these interactions surveys, quiz, or materials using gamification can be used, these are stand-alone methodologies very welcome, not discussed in this paper.

7. TEST THE ROUTE

Never conduct a walking tour for the first time with the final public invited. A test walk should be made, possibly recorded, the timing evaluated. Other professionals or related stakeholders can be invited to such test walk to help to complete the walk itself. If the walk became too long or short, if other problems emerge, a readjustment must be made and the test should be done again.

8. DO THE WALK

The main point of this process is to gather a number of participants relevant to the goal of the process, and do the walk. Have plan B for bad weather or any special occurrences! Pre-register the participants, and make a clear communication with them about the date, starting point, ending point and all infos. The goal of the walk must be clear also to the participants since the beginning!

9. INTERACT, EVALUATE AND PROCESS

It is essential to evaluate the walks, collect data from participants, and see how successfully the goals were achieved. On-site questionnaires, on-line forms (if possible collect the contacts of participants!) after the walk are suitable for this purpose, ask simple questions that are easy to answer! However, discussions and questions during the walk itself are the most useful to measure the attitude of participants and to see the effect the walk has on their perceptions.

If the purpose of the walk is to INVOLVE the participants, for example to have their opinions about the reconstruction process, the INTERACTION during the walks is the most important part of the process. During the walk plan ahead to leave enough time for discussion on the key stops of the walk. Plan which topics to discuss where, and what outcomes you want to arrive to. Have an effective way to take notes: for walks with real interaction the guide should be helped by at least one person who manages the group, takes notes. But in occasions where the walk is an important participatory event more than two persons should be in the group of the guide, taking notes, but also asking questions from individuals, helping to channel the inputs of individuals, isolating discussions which are not relevant to the topics to discuss and opening up questions to the whole tour which are relevant. Participants of the walks have to have the occasions to express their opinions, for example by selecting between scenarios discussed and presented on-site, even with the help of plans and images presenting these scenarios. The results of discussions and also of direct voting and questions results should be meticulously collected, documented and evaluated after the walk.

10. CREATE A MAP OF THE WALK TO MAKE IT WORK WITHOUT A GUIDE

A useful tool to preserve the knowledge base built up during the walks is to make graphic maps from the walks. These maps should be informative, graphically elaborated ("beautiful"), easy to read and follow. The insights, added stories and content, and also discussion results of the participants of the walks should also be elaborated into these maps, documenting all the process this way. Maps should have:

- Maps with a graphics easy to follow and recognize.
- A graphic design that is attractive and express the identity of the place and topic..
- All points of the walk should have a text/image field where that stop is explained.
- Images should be either photos or drawings pointing out the main features of the stops. Don't use plans of buildings or future designs!
- Text should be more informal and interesting than factual, but main data must be presented.
- Title, introduction cover page must be designed for to-the-point understanding.

Case study

The Budapest University of Technology and Economics (BME) in collaboration with the NGO Hungarian Contemporary Architecture Centre (KÉK) developed urban walks in order to involve the local society in the discussions about the reconstruction of the Castle District of Buda. The need was eminent, as after 2010 the government of Hungary decided to initiate a large reconstruction process for all of the historic district, meant to reconstruct most of the splendor of the pre-war Castle District, but this decision was totally centralized, the

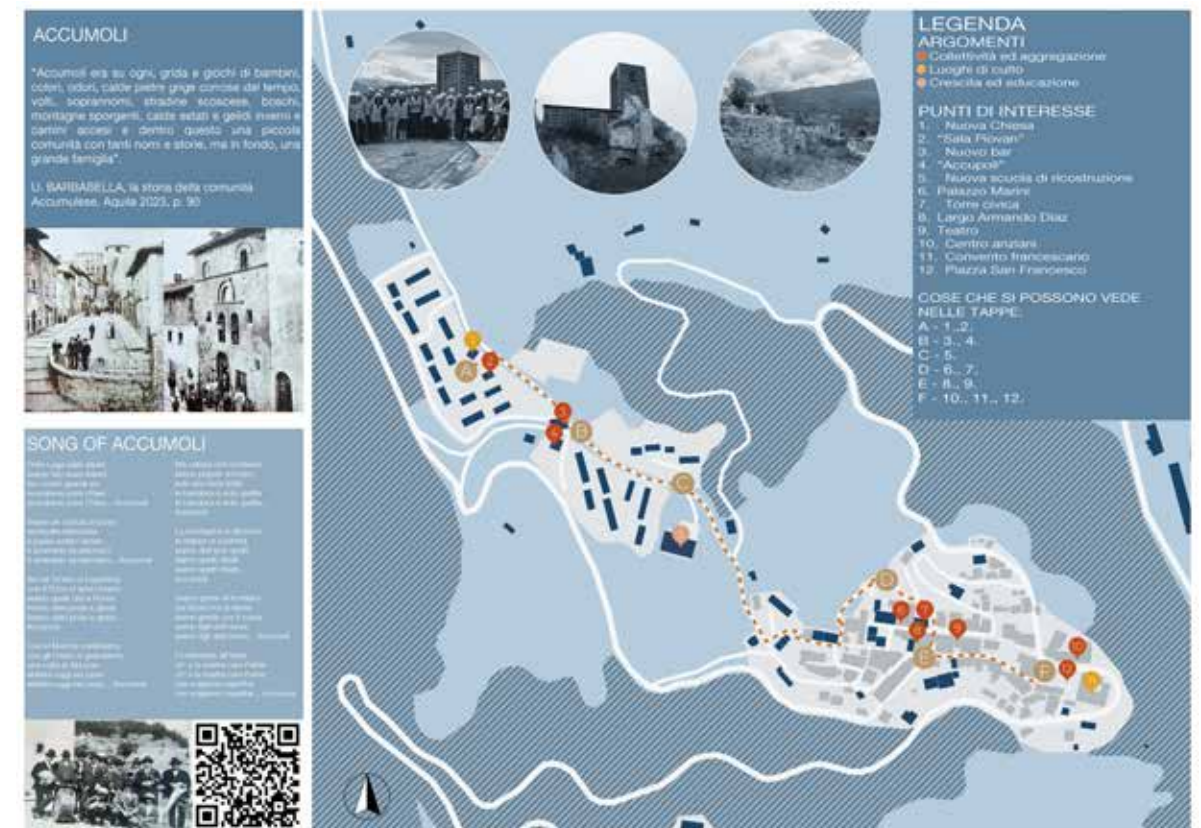


Fig. 2 One side of the printed-foiled map of an urban walk compiled by students in the ComPaRe workshop of May 2024 in Accumoli

plans created without any competitions or open processes, and the reconstruction plan – called Hausmann plan – contradicted most of the values of the previous reconstruction efforts after World War II. The main contradiction was that the government decided that the pre-war state was the one to reconstruct, while post-war professional efforts criticized much of that state, as large scale developments in the end of the 19th and beginning of the 20th centuries overbuilt the medieval and baroque structure of the Castle Hill, and made fancy palaces that were 2-3 levels higher than those from historic periods, occupying the place of 3-8 of the original plots. In present day professional critiques have been the same, as these palaces will alter the historic scale and image of the district – meticulously reconstructed between the 1950s and 80s, and erase many of the architecture from this modern period that were exemplary designs fitting the context.

But how to convince the general public to defend architectural values of late modernism implemented in communism, when for non-professionals the fancy eclectic architecture of the early 1900s seems much more historic than the preservationalist attitude of late-modern architecture?

Urban walks created by KÉK and BME always focused on the original medieval and baroque values of the castle district, presenting the developments seen as different layers done in later ages. The main goal of the walks was to highlight the pride in having a medieval-baroque civic city as the origin of the Hungarian capital, and to show how in some ages this base had been disregarded by power and personal interests, while in others it had been preserved and continued because of deep professional interest and for the benefit of the local population (in the late 19th century and today the focus of the developments have been the institutes of the state, while in the post-war period the will to construct a living neighborhood). The walks presented the destruction of the wars (mainly the Turkish occupation and wars of 16th 17th centuries and the II. World War), and the methods of reconstruction after these. The walks built successfully on the pride of the local population in their historic centers, and could transform the negative perception of post-war reconstruction into a positive one, and could help to build a criticism regarding the present Hausmann plan and reconstructions going on, pushing people to be interested in the reconstruction process and to hear their voices.



Fig. 3 Flyer inviting the public to the Urban Walk presenting the heritage created in the 1960's in the historical Castle District of Budapest (KÉK, 2024)

Conclusions

The example of the Castle District shows that the understanding of the various layers of history and the motives of the various reconstruction periods can help to understand why reconstruction after a disaster leads to dangerous cultural choices affecting the notion of authenticity, but also that of liveability and long term social and environmental sustainability. In reconstruction projects even cultural conflicts must be revealed and mediated, and the tool of urban walks has proven to be effective in order to ensure the basis of participatory reconstruction in a complex cultural context.

Urban walks are appropriate tools to reveal the complexities of the urban and historic context of a city, creating the basis of a common understanding of the values of destroyed urban environments. This tool aims to involve decision makers, local communities and specialists of the physical reconstruction, creating a common understanding of values only possible on-field, inducing discussion and story-sharing, giving a common point of starting for the reconstruction process, but also a common understanding of the reconstruction process during its implementation.

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EFFECTIVE STRATEGIC TOOLS FOR ENVIRONMENTAL AND SOCIAL REGENERATION

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"All stakeholders in the disaster management system must find their specialized place and role."
(Hoffmann, 2011)

MAIN DATA OF THE EVENT:

Kind of disaster: Toxic red sludge disaster

When: 04. October 2010

Lost heritage: More than 300 houses were damaged.

People loss: 10 residents dead, 123 people suffered serious burns.

Abstract

Procedures for post-disaster reconstruction in different countries can differ in many aspects, according to different traditions, legal systems and administrative structures. The aim is therefore not to present the Hungarian situation in detail. The effectiveness of the recovery from the red sludge disaster in Hungary was obviously determined by the state's – legally declared – strong role. This guaranteed not only centralised, hierarchical control, but also the priority of the proceedings at all levels and in all areas. However, it is important to highlight - as a crucial aspect - the fact that a protocol already existed through previous experience (flood in Felsőzsolca), which made it possible not to build an action plan from scratch, but which can be adapted to a given place and situation.

In the present context, where the ultimate goal is to develop an educational programme with a diverse approach and tool system, one of the priorities is to sensitise architecture students and help them to understand that their future role is not limited to professional participation in a narrowly defined design task. They need to be made aware that, in addition to seeking for idealised and ideal design briefs, architects need to understand, recognise and assume a human and professional role in social and community-type tasks and situations. In this respect, the situation for architects is favourable, as demonstrated by the case study described earlier (Chapter XY). After all, from the point of view of creating a situation of trust, the helpful cooperation and presence of the various authorities, and the temporary establishment of the authority groups on site were in vain. No one has been able to build personal relationships as effectively as architects, who - while discussing with each person/family individually their needs, requirements and expectations - gained the most in-depth knowledge about family and neighbourhood relations, lifestyles, habits and relationships.

Goals - Understanding the role of the different actors in the physical recovery of the environment and the mental recovery of the locals

In post-disaster revitalisation, the process of damage repair and reconstruction is equally important, both for the built and natural environment (physical) and for the society affected (mental). While the former is aimed at assessing and evaluating environmental hazards and risks, localising the effects of damage that has already occurred, preventing further spread, restoration and repair. In the latter, while in addition to dealing with past and present events, the reconstruction and rebuilding is part of a process of presenting the future and has a different content/importance. In its case, in addition to the physical, the mental construction is an important element. The tragedy experienced cannot be forgotten, but it can be dealt with the hope of a new beginning of some kind; making decisions about it, possibly organising activities. Active participation requires intellectual and spiritual presence, it does not allow turning back completely to the past. This is why it is

essential that victims are not passive members of the process, but are involved as intensively as possible. It is therefore necessary to define what kind of role they can have in which activities - only informed ones or as contributors, with electoral or decision-making powers? It is also essential to clarify the competences, so that it is clear from the beginning how deeply they can flow into it, and what they can influence in a meaningful way.

Shared tragedy can have a powerful community-building role, but it can also create divisions. Who has suffered greater losses, who is more vulnerable, who needs more help, who is better at managing opportunities? - can all be divisive and conflict-generating issues. In addition to psychologists, coaches, mediators or therapists should be involved in dealing with these issues, who, instead of spontaneous, whispered conflict generation, use professional problem-discussion and conflict management tools to help the open communication. At the same time, there can be no doubt that in many places this type of conflict management can cause difficulties and anxiety on the part of already suspicious and distrustful communities. It can help a lot if there is a local, charismatic figure – in a fortunate case a local leader - who has sufficient influence and acts as a “bridge-person” between the stakeholders. Personal contact, knowledge of and trust in internal relationships not only can support professional helpers from outside to understand how the community works, but can also be an important aid in developing the necessary steps for community building/strengthening.

Architects and urban planners typically lack the training and professional routine needed to moderate psychological processes. They are primarily in a favourable role mainly where individual/family-scale intentions are processed and managed. At the same time, they are involved in the processes on several levels that are linked to the shaping of the wider environment and are physical, so they can be understood and tangible. Part of the process is the interpretation of the physical imprint of the public space system as a community living space and to revitalise the settlement life and operation that can be associated with it. As part of the planning/renovation processes, the functioning of the damaged areas should be investigated, and the physical, operational and spatial/social characteristics of the former public space system and its individual elements should be assessed, which should and can be retained and preserved as assets in the newly built areas as well. In what way can these values be interpreted and translated into today's formal languages, public spaces and architectural tools? The participatory planning method can be applied here – in the case of disasters - in a field that is truly a community issue, and because of its physicality, scale and character, it raises questions and offers answers that many can understand, even without any professional knowledge.

The function, location and design of common areas are of great importance to the local people, who feel involved, and therefore they want to be engaged in the related decision-making process. However, there are always a significant number of passive people who either do not consider themselves competent or, because of their personalities, refrain from making decisions or expressing opinions on community-type issues. Reaching out to them, activating them, getting them interested is a type of task that an urban planner or an architect should be willing to take on. There is no doubt that the success of this is not necessarily a matter of design skills, but also of personal attitude and communication skills.

Local people, however, are mostly affected during the rebuilding of their own home, and therefore they can identify with the rebuilding process the most in that phase. This is the scale and sequence of events where the role of architects (and urban planners) comes to the fore. Not only as professionals who influence the shaping of the personal physical environment, but also as designers who can fine-tune the development of community and social relations through the public spaces associated with it. Everyone is most concerned with their own fate and that of their loved ones; so, it makes sense to approach the issue of public spaces from this perspective, and to schedule them so that they do not precede consultations on individual plans by much. Furthermore, at all levels, it is important that victims do not receive ready-made versions or visions, and make it clear that they are in a working state, so people feel they can get involved at a meaningful and variable phase of the process. It is necessary to make them feel that nothing is set in stone yet, because their opinions matter.

After the red sludge disaster, for example, architects presented their first concrete, but still sketchy, building proposals to the local population at a meeting. In doing so, they not only demonstrated that planning work is indeed underway, but also indicated that their aim is not to accept already decided, ready-made facts, but to think together and engage in dialogue. They tried to treat the reconstruction process as an opportunity to solve problematic issues in the previous living conditions within the framework of a tabula rasa; such as uncomfortable or conflicting neighbourhoods, difficult-to-resolve special family situations, etc.

During the work process, residents were able to mark on a posted map which plot they would like to choose. The real challenge was the settlement where the destruction affected more than one row of houses on a street. In Devecser, reconstruction did not simply mean building a new part of the settlement in a new location. Due to the variety of options neighbourhood relations also changed, as only about a third of the victims wanted to build on site. (Fig. 1-2.)

Later, there was a multi-stage consultation with residents on the concrete building plans. Several basic type plans were prepared for an announced architectural "house tender". Based on the floor area, the affected residents were given a choice of around 3-4 houses, and later during personal consultations, they fine-tuned the size and functional requirements. During the consultations, each family had 1 hour each, but they could come more than once. (Csóka, 2021a) (Fig.3.)



Fig. 1 Devecser, division of damaged areas (Csóka, 2021a)



Fig. 2 Devecser, division of the new residential area (Csóka, 2021a)

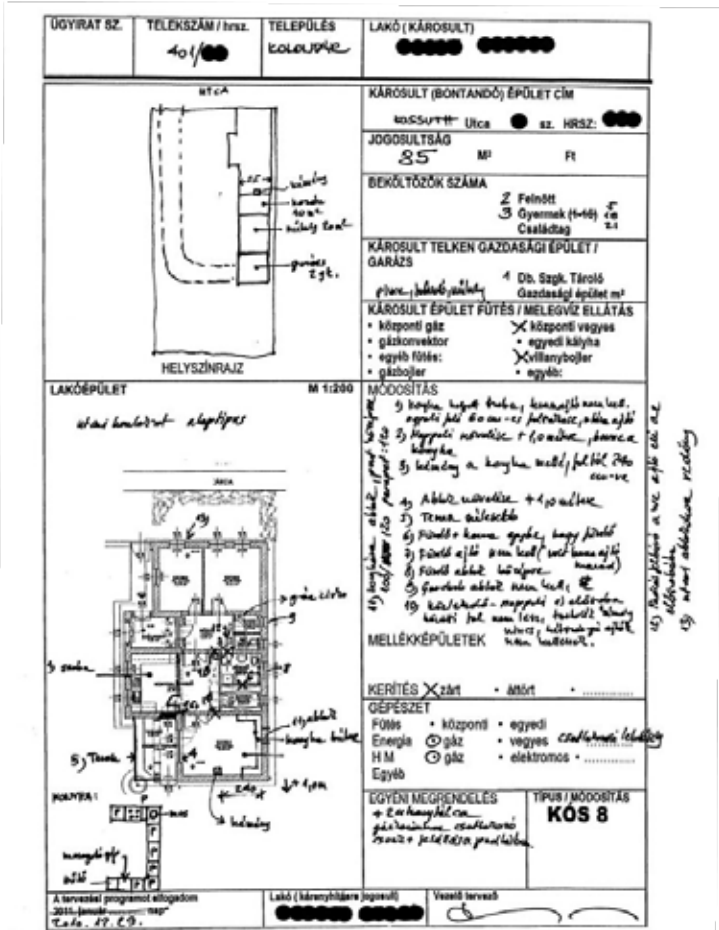


Fig. 3 - Residential consultation and adaptation sheet (Source: Csóka, 2021a)

Methods - Creation of a role-play model as an educational method to reveal the responsibilities and competences of the actors in a reconstruction process

Since a personal relationship with the locals can be assumed, the designers have a communication channel at their disposal that almost none of the other professionals involved have. Engineers guarantee safety, but they often look beyond the personal, individual scale and focus on highly specialised professional issues, the content of which is often incomprehensible to the layman. But sociologists, psychologists, therapists do not create physical value, so without an objectified form, the importance of their contribution cannot be understood by many.

As soon as the future, the new beginning, is on the agenda, urban planners and architects must be present. They should help to decide on the location of the new constructions and on the formulation of the planning principles for the new settlement areas. For this, the settlement heritage, landscape connections, structural, morphological and infrastructural features, and the possibilities offered by the regulation plans in force must be evaluated. However, these also must be compared and aligned with the attachment, the desires and objections of the population. Unfortunately, often there is not enough time to consider these issues precisely, because of the pressure of rapid construction, even though their role is of paramount importance in the long term.

Fortunately, in the Hungarian case, the affected population was involved in the reconstruction process at several levels, but mainly – we can say - in the building planning. They have also tried to accommodate their wishes on a smaller but also on a larger physical scale (Fig. 4). Specifically taking into account the wishes of the population, while in Kolontár – which suffered less damage on a settlement scale -, the newly designed one-street row of houses was rebuilt not far from the destroyed area, then in Devecser, the intention was clearly to position the new construction far away from the former residential area that had experienced the disaster, without even a visual link (Interview).



Fig. 4 Victims and their new houses 10 years after the disaster (photos: Tamás Szántó; source: Csóka, 2021b)

The process of designing individual buildings, although lengthy and meticulous, is perhaps less complex from a decision-making point of view due to the smaller number of people involved in each case, and therefore more familiar to architecture students. But an urban planner and architect can do more. As mentioned above, they can play a key role in the reconstruction process. Not only in the actual physical construction process, but also in the spiritual and mental recovery and rebuilding of individuals and communities after a disaster. How to help the affected community with plans is evident in many ways. However, the actual content of the design-presentation-drawing and drawing-communication process sequence and how it can be applied at different levels as a tool for reconstruction is still to be learned. It is therefore necessary to include in the education program of architecture/urban planning/urbanism students the types of roles that post-disaster reconstruction may impose on them compared to traditional design methodologies. At what stage, what they are expected to do, in cooperation with whom and with what powers? Namely, only some of them fit into traditional planning competencies and tasks.

For this reason, we propose the so-called role-play model as an educational tool.

Tools and process- Using the role-play model to promote the learning of cooperative thinking

Contrary to its name, role-playing is clearly not a game, but a teaching method that favours active participation rather than passive transfer of information. In contrast to traditional education methods where the instructor or lecturer passes on the experiences they have gained; the aim of this method is to encourage students to think individually and to come up with their own proposals, with external help. It can also help to learn cooperative thinking, the basics of strategic planning, reasoning and effective communication.

The process of our proposed method is as follows:

The exercise consists of two different parts; I) the first aims to understand the whole renovation process and the roles of all actors involved (I. Participants and role-takers); II) while the second will focus specifically on the content and importance of communication between architects/urban planners and local residents (II. The role of architects and urban planners). The dramaturgy is similar in both parts. The task is prepared by the teachers, who establish an initial situation - a real case or a fictitious one - and then moderate the whole process. During the preparation (by walking around), they assist each group to organise their ideas and thoughts, during the work process they help to identify conflicts of interest, to communicate properly between the parties and then, after a consensus, to formulate a joint action plan.

I Participants and role-takers

1. Preparation

Adapting to the situation given by the teacher, the students map the problems and identify the actors they consider necessary to be involved in the reconstruction process. Possible options include:

- Residents
- The responsible / who was/were to blame for the tragedy
- Decision-makers
- Disaster Management Agency (The Directorate General for Disaster Management)
- Mayors / Local governments
- Local entrepreneurs
- The Church / NGOs
- Architects, engineers (Association, Chambers, Universities....)
- Coaches, Psychologists, Civil society helpers
- Others

But different, individual contributors can be assumed for each country.

2. “Casting” – the allocation of roles

Students choose a role in pairs or small groups depending on the number of them. (In a case of a small number of participants, one student is assigned to one role.) The local resident and urban planner/architect actors are always required.

3. Action plan scenarios - developing an action plan

The groups separately formulate and summarize in writing (projected, on a blackboard or on large sheets of paper):

- the potential new risk elements;
- the short, medium and long-term actions they consider necessary;
- their timing and their relation to each other;
- their own group's role in the whole process;
- what their responsibilities and priorities (if any) are.

The instructors walk around and help each group in formulating the above points. Their role is not to lead, but to assist to validate the methodological aspects.

4. Arguments and counterarguments

The groups present their developed schedule and action plan, and listing their arguments. In case of conflicting opinions, a consensus solution is sought through discussion facilitated by the teachers.

5. Finalising the joint action plan and summarising the lessons learned

Each group agrees on a solution proposal based on a common understanding for the previously given problem, taking into account the needs of as many groups as possible. In addition, a "working diary" is kept to show the active role of each group, the goals achieved, the communication tools and lessons learned during the process.

II The role of architects and urban planners

1. Preparation

Students choose roles in pairs or small groups, depending on the number of them.

- local residents
- local entrepreneurs
- urban planners, urbanists
- architects

2. Question-and-answer session and dialogue

- Residents and local entrepreneurs set out their general expectations and concerns
- Architect and urban planners set out their priorities, their tools, the main issues and methods available to them and the type of aid they expect from the local people
- Possible options:
 - Public space value register: This will include a series of questions to the residents, focusing on the following main issues: Which previous elements do the locals consider important in the past life of the settlement? What did they do there, what time of the day did they use it? Was there a public space/ green/architectural feature that was important to them? Why did they love it? ... etc.
 - Functional analysis: What were the main functions in the area? Who used these features, when and how often? What was missing? ... etc.
 - Historical value analysis: What architectural, historical, green space and cultural value would you preserve? Do you remember any stories about the settlement/street/building etc.?

3. Comparison of aspects, seeking consensus on controversial issues

From gathering the "dreams and needs" of the local population, to developing a "common concept" and discussing the "budget and the tools available to planners", to the preparation of a final plan, a joint "action plan", it is necessary to go through a number of participatory planning stages and consultations. This requires effective communication. Without which, the discussion and negotiation of ideas and problems that arise at each stage, and the development of options and final action plans would not reflect the actual individual and community needs, but only the assumptions of the planners.

4. Final result

Joint definition of a construction action plan, with a timetable and tools.

Conclusions

Participatory planning can help to integrate the interests of different stakeholders (official person – designer/ planner - community, etc.), by opening appropriate channels of communication between them and thus clarifying conflicts that may arise. And the presence of local people can help to identify the "real" problems and plan and implement solutions accordingly. The "democratisation" of planning can thus lead to better quality decisions and can also have a community-building role, because where the will of the community prevails, based on the knowledge base of the locals, the social acceptance of the plan and the implemented condition is higher, which is essential for the long-term success of the reconstruction.

The role-play can help to understand this process. As a (design) tool is useful for teachers and students alike, especially where there is a tradition of one-way knowledge transfer based on instructional communication and accountability. By getting everyone out of their comfort zone, the method can encourage them to come up with creative, unique solutions, rather than using tried and tested communication tools.

Understanding the complexity of such a sensitive, unconventional, site-specific and situationally associated topic as post-disaster reconstruction, it is also necessary to use non-traditional methods!

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Interviews

Interview: dr. Annamária Gerzánics; Certified landscape and garden engineer, urban planning and urban economy engineer, retired Deputy Director-General of the Department of Spatial Planning and Urban Affairs of the Ministry of the Interior ... [time of the interview: 2024. 03.13. 13:00-16:00, location of the interview: BME, Department of urban planning and Design, 1111. Budapest, Műgyetem rakpart 3. HU]

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MAKING HERITAGE RESILIENT: A GUIDE FOR MANAGEMENT INVOLVING LOCAL INHABITANTS

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Abstract

The chapter underlines the necessity to collect and study data on any disaster causes and impacts in all spheres of the functioning of society. Detailed knowledge of endangered entities, including their quality, status and evacuation options, is essential information. It is also necessary to record the behaviour of the inhabitants, their human and psychological attitude to the disaster. Lessons learned from the devastating flood in Central Europe in 2002 is further used for concrete description of an assessment of vulnerability and resilience potential of heritage assets. According to the sensitivity of heritage object to disaster loadings or actions, a scale ranking the object resistance has been designed. Similarly the state of managerial preparedness is evaluated and categorized. Preventive measures and priorities are then associated with the above mentioned ranking with typical general features. In order to engage and enable an active participation of stakeholders in preventive risk reduction strategies, especially of non-technical users of cultural heritage asset, it is necessary to provide them with user friendly accessible and comprehensive methods for vulnerability evaluation. The novel concept of criticality was developed and introduced. Criticalities are defined as factors or aspects of a system with cultural heritage values decisive for survival and recovery in the face of natural disaster and other global threats. Critical elements and parameters can be modified with suitable measures, interventions or actions that improve the resilience of the system. The advanced knowledge enable preparing of management tools, especially regular inspection and maintenance plans, and emergency plans. Manuals for stakeholders support their involvement in self-assessment action and early discovery of criticalities decisive for damage during disasters. The use of developed support tools in risky situations must be mastered and practically trained by the future users.

Introduction: data collection and detailed analyses of the disaster impact

Any natural or man-made disaster is very painful for society and individuals and brings much suffering and material damage or losses (Bonazza et al., 2018). However, the path to a resilient cultural heritage begins at the moment of an event. If we understand disaster as an unplanned experiment, it also becomes a source of very useful information for the design and adoption of measures to prevent or reduce as well as treat the consequences. It is therefore one of the important tasks of every disaster to collect and study data on its causes, intensity and impacts in all spheres of the functioning of society. In the area of risk management, detailed knowledge of endangered entities, including their quality, status and evacuation options, is essential information and must be investigated. This also presupposes detailed knowledge of access and evacuation routes, the readiness of spaces for the gathering of affected persons or the storage of relocated artefacts. It is also necessary to anticipate the occurrence of obstacles caused by disasters that may make transport impossible. Local authorities must work closely with citizens and property owners in emergency situations, which requires the best possible communication, providing early warnings, instructions on ready or available help from professionals and rescue teams. Specialized engineers must inspect damaged buildings and structures to determine their condition. Such inspections are precisely an opportunity to investigate the effects of a disaster on materials and structures in relation to the forces or actions applied. Buildings without serious defects can then be opened for use after the deficiencies have been removed. Objects with more serious failures must be secured by technical means or even removed. It is also necessary to record the behaviour of the inhabitants, their human and psychological attitude to the disaster and the need to deal with unexpected situations and uncertainties for the future. Let us take the example of the devastating flood in Central Europe in 2002, which affected all Central European countries and many listed buildings, territories and works of art or history, including family heirlooms.

Lessons learned and ranking of heritage objects according to their vulnerability or resilience

Architectural heritage, historical infrastructure and objects of art are subjected to various forces and actions during flood events often not usually considered in the design of structures. The causes of damage can be categorized according to the types of impacts that they can cause. The categorization helps to develop preventive, protecting or remedial measures. The following types of loads or actions are typical in flood situations. Horizontal static pressure of raised water creates loads proportional to the height of the water. It can damage or even destroy long free-standing walls, (Fig.1), basement walls, retaining walls or shutters of building opening.

Upward hydrostatic pressure raises all moveable objects in interiors, and typically unhinges doors, raises floors, roofs and whole objects, decreasing their stability against overturning. It may also cause water penetration through sewerage systems into areas protected by vertical flood barriers. Velocity water stream actions, especially dynamic high-velocity streams can have an extremely dangerous impact on structures. They typically damage the banks of river channels, and are responsible for most of the severe damage to bridges, and also to earth structures. Wave impacts are typical for sea storm or river flash floods, and they can destroy or displace whole structures and objects, e.g. small buildings or sculptures in valleys. Dynamic impacts of floating objects mainly endanger bridges, water mills and other objects inside or close to river channels. Water penetrating through particulate media can wash out fine particles and cause remarkable compacting and subsidence. Further subsoil condition changes may initiate several types of failures, i. a. collapse of retaining structures, landslides or debris flow due to a change in groundwater level. Full immersion into water accompanied by saturation of materials causes a wide variety of actions and damage related to volumetric changes, chemical action and loss of strength (Drdáký, 2010).



Fig.1 The Collapsed late Baroque stone masonry garden wall in Troja Chateau – Praha 7 (flood 2002). © M.Drdáký

According to the sensitivity of heritage object to flood loadings or actions a scale ranking the object resistance has been designed. Five grades of objects include: F0 Flood-resistant structures and buildings, F1 Structures made of materials with a high volumetric change due to moisture, F2 Structures made of materials that lose their strength to a great extent when subjected to moisture, F3 Structures susceptible to partial damage due to flooding and F4 Structures and elements vulnerable to overall collapse or displacement due to flooding. Each category is described with characteristic features and examples of typical damage accompanied with examples of objects. For example, F0 is characterised as objects in which no structural or material damage is apparent during and after flood. Typical impacts are observed: water saturation and high moisture of materials and structures, soiling, infection by microorganisms, unhinged doors and similar. Robust objects made of water resistant materials (e.g. granite or similar stone, metals, mechanically resistant stone masonry, concrete) represent this grade. Further, F1 ranked objects experience damage associated with volumetric change – usually irreversible – change of shape, cracks, and deflections; Spalling of surface layers; Moisture expansion may cause damage of masonry – origination of cracks or even shifting structural parts; Bowing of wooden floors; No dangerous loss of strength and load carrying capacity reduction. Typical representatives are timber structures and elements, combined structures made of materials with different moisture expansion – e.g. combined timber – masonry objects, and clay soils. F2 category features materials fast degrading and losing their mechanical characteristics due to high moisture or water saturation, which induces significant reduction of load carrying capacity of structural elements or subsoil and may cause fatal failures during flood or after it, (Fig. 2). Dried brick (adobe) masonry, masonry of burnt bricks or sensitive stones (sandstone) with clay mortars (with a low lime or cement content), decayed timber structures and elements, infill subsoil and fine particle subsoil. Similar ranking has been developed for other types of disasters: landslides, windstorms, earthquake, harming weather effects as well as for other types of cultural heritage, such as cultural landscapes, terraced landscapes, depopulating hamlets, gardens and parks or shore areas.

Similarly, the state of managerial preparedness is evaluated and categorized taking into account various levels of governance structure. This can be illustrated with examples of robust information system (data concerning CH assets are complete - maps, condition assessment of objects and records of contents –



Fig.2 Failed biodegraded timber floor joists in a historic house in Prague Troja during the 2002 flood, (the house was totally immersed in water). © M.Drdáček

accessible to all relevant stakeholders and up-to-dated) or knowledge and awareness are ensured (all stakeholders including managers, owners and general public are aware of CH assets at risk and trained for emergency situations). On the other hand, lack of maintenance plans represent a lower degree of preparedness (proper maintenance is missing inducing in some cases bad functioning of protection or drainage systems, fittings etc.) (Bonazza et al., 2021).

Design of preventive, rescue and remedial measures for the ranked heritage objects.

Preventive measures and priorities are associated with the above mentioned ranking with typical general features. For the F0 rank objects, no hard measures are necessary – only recommended preparedness facilitating cleaning and drying after the flood, for the F1 rank objects, prevention of contact with water – if possible (plastic wrapping, protective coats etc., creation of dilation gaps between timber and masonry). In the F2 rank structures, critical structural elements require assessment of their load carrying capacity by professionals and the structures usually need temporary supports or permanent strengthening before flood situations, and evacuation of moveable objects is recommended. Where the situation and financial resources allow, it is advisable to use territorial protection by means of mobile or stable flood protection barriers.

In order to engage and enable an active participation of stakeholders in preventive risk reduction strategies, especially of non-technical users of cultural heritage asset, such as owners and managers, it is necessary to provide them with user friendly accessible and comprehensive methods for vulnerability evaluation. Therefore, the novel concept of criticality was developed and introduced. Criticalities are defined as factors or aspects of a system with cultural heritage values decisive for survival and recovery in the face of natural disaster and other global threats. They represent a more delicate scale of vulnerability assessment. Critical elements and parameters can be modified with suitable measures, interventions or actions that improve the resilience of the system. Criticalities are hence measurable and controllable. The methodology proposed considers two main groups of criticalities, which characterize cultural heritage systems, namely managerial and physical criticalities.

Managerial criticalities relate to those aspects which are not connected to the physicality of the cultural heritage assets but rather to their operation, administration and care. Managerial criticalities include the following categories: information concerning cultural heritage object, funding availability and accessibility, knowledge and awareness, cultural heritage management planning and policy and regulations. Examples of managerial criticalities are the lack of knowledge or information, negligence (lack of maintenance), inadequate decision making, poorly designed emergency or post-disaster plans, missing funds etc. Each managerial critical element aspect is strongly context-specific and requires an accurate assessment and thoughtful prioritization in order to reduce the risks related to natural or man-made hazards and improve the resilience of the overall cultural heritage system.

Physical critical elements relate to the aspects of a cultural heritage system involving its actual material composition and structural conditions. The sensitivity of historic structures and structural elements to disasters is influenced by material and structural capability to resist exceptional loads and environments during disastrous situation. Also physical critical elements are significantly context-specific and require a thorough investigation of material characteristics and the general environmental situation (e.g. hydrogeological conditions) before being adequately evaluated. It should be emphasized that there exists a wide range of historic structures and materials, and also a wide range of types of damage. This makes it difficult to design widely applicable measures and unified methods.

Preparation of management tools for damage prevention or mitigation

Experience from natural disasters shows that the extent of loss and damage is highly dependent on the condition of buildings and structures (Fig.3). Poor quality and neglected maintenance of buildings reduces their ability to withstand destructive forces.

Structures and buildings usually do not have instruction manuals and maintenance schedules. Successful preventive protection requires developing such tools and making them available to stakeholders. The maintenance action is usually initiated as a result of the regular inspection or it can be carried out really



Fig.3 Example of damaged areas of poorly maintained buildings (Haiti).

regularly on a basis of maintenance plans, which is a better and recommended standard approach. The maintenance action in most cases does not need design work or even an engineering supervision. It can rely only on skills of properly trained craftsmen, which substantially shortens the time to action and prevents development of a defect into a more serious damage or even a failure. A maintenance guide is a useful tool and should combine tips for inspection with recommendations how to fix an identified problem. It is the follow-up activity to remedy the identified deficiencies that is the most important. Mere knowledge of defects and weaknesses without remedying them as quickly as possible does not bring the desired benefit. An example is the earthquake that struck Christchurch, (NZ) where there was a detailed plan of the condition of all buildings with regard to the earthquake resistance, but no action was taken and the extent of the damage was great.

Emergency situations require preparing of emergency plans which is mainly a task for governing authorities. The emergency plan is typically composed of above mentioned risk assessment and protection measures, availability of resources, involvement of public emergency services, development of emergency response plans for individual buildings or companies, which also include evacuation plans, medical emergency, fire emergency, shelter planning etc., accompanied with training and exercise to practice. Protection against looting also needs to be provided during a disaster. Over a larger area, a help of the army is invaluable in this service. The inclusion of boy-scouts familiar with the local situation and residents in mixed patrols with soldiers has also proven to be effective.

Stakeholders' collaboration with local risk management authorities

The concept of resilience indicates the ability of a community or urban unit to withstand shocks to its survival and to absorb changes without a transition to a different state. In other words, resilience represents the capacity of a system or object structure to absorb disturbances and reorganize while undergoing under the effects of change so as to while retaining essentially the same function, structure, identity, and feedbacks. Three aspects of resilience are involved in responses to disasters and all are important for cultural heritage.

Physical resilience – refers to the ability of a city or community to rebuild its physical structure. Emotional resilience – refers to the ability of individuals, families and communities to cope with and heal recover from trauma. Last but not least cultural resilience is not discussed here.

Disaster affects many buildings as well as a large variety of moveable family heritage, requiring the involvement of owners in effective resilience preparedness. Such an approach entails providing them with adequate supporting information and sources of advice. Therefore, it is believed that manuals for condition self-assessment and for the adoption of appropriate actions before, during and after any disaster will help to reduce damage and loss from natural and man-made disasters.

Self-assessment and enhanced resilience methodology is based on the identification and modification of manageable or steerable critical elements in a system. As already mentioned, the critical elements in systems with Cultural Heritage values are understood as factors or aspects of a system decisive for its survival and recovery at actions in the face of natural disaster and climate change. Such elements can be modified with suitable measures – interventions or actions – that improve the resilience of the system. Guiding manuals should classify criticalities into three groups depending on the type of situation in which the assessment is carried out: - Site criticalities. - Building criticalities. - Moveable heritage criticalities (including family heritage). Each criticality should be dealt with on an individual page (table) of a manual and the following data or information provided: Hazard or disaster scenarios relevant to the criticality; Criticality description; Typical damage or failures caused due to the presence of the criticality in relation to the given hazard; Possible measures for improving resilience, which can be implemented in different phases of a disaster, i.e., before, during and after the event.

Each measure should be labelled (using a colour code) characterizing its mode of applicability: measures that can be performed by the owners themselves, measures that require the involvement of skilled labour and should not be performed by the owners themselves, and measures that require professional engineering or conservationist assessment prior to implementation.

Such manuals should be used in the preliminary vulnerability assessment of cultural heritage assets and should be employed only as reference materials. However, they can help to accelerate the identification and repair of criticalities that may lead to damage during emergency situations. They further prevent losses due to the inappropriate treatment of cultural heritage assets affected by disasters. The first edition of such a manual has been developed in the framework of an international Interreg CE project and focused mainly on floods, heavy rain and draught. (Drdácký et al., 2020) Special attention was paid to movable monuments and family cultural heritage, as they represent the groups most at risk during floods (Fig. 4). The manuals are available on the web in eight European languages <https://doi.org/10.21495/53-6>.

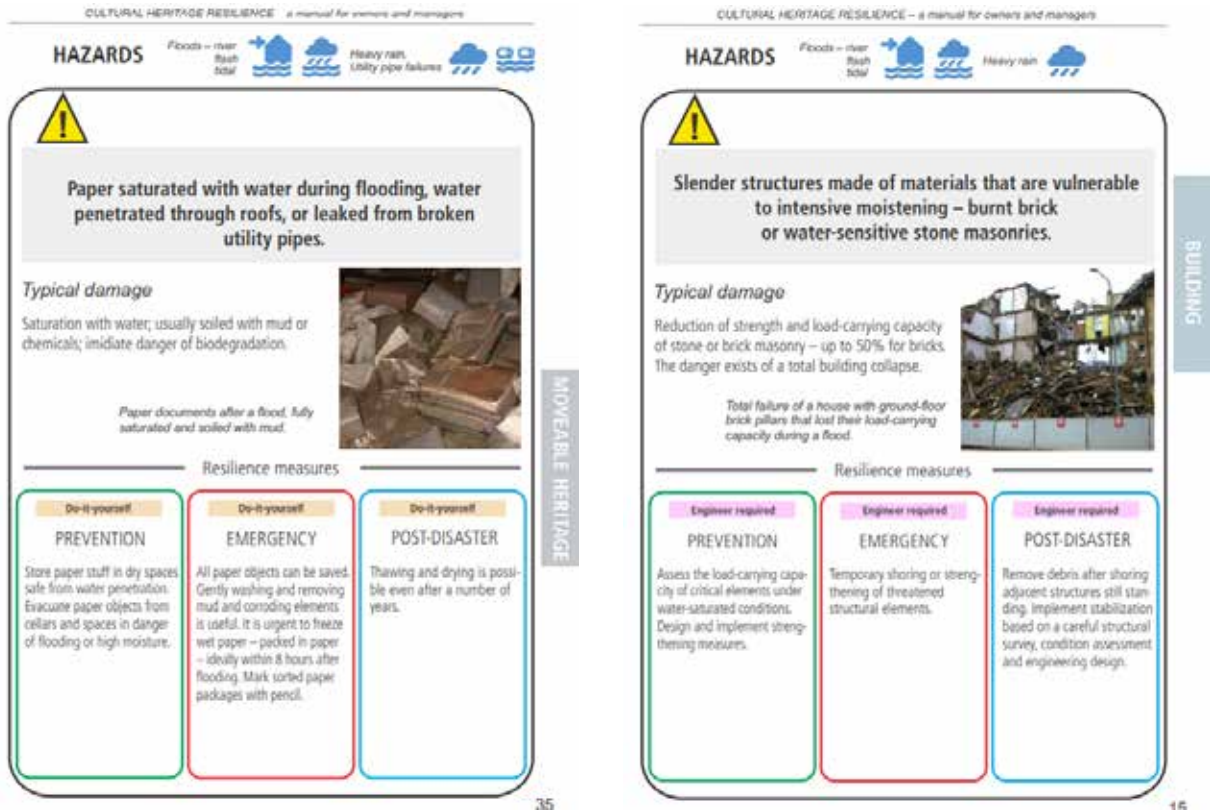


Fig.4 Examples of pages of the manual for stakeholders. (Drdácký et al., 2020).

This manual is supplementary to the institutionally provided civil protection tools aimed at increasing the resilience of assets having cultural and historical value and which are threatened by critical scenarios or have been hit by natural or man-made disasters. It is primarily intended for the owners, administrators, or users of such cultural heritage properties and objects, but also provides useful information and advice to citizens and institutions in crisis, especially civil protection rescue teams and their auxiliary units.

Training of local inhabitants in application of supporting tools

The developed support tools for behaviour in risky situations must be understood and mastered by future users in the form of teaching and practical training. In the case of temporary technical means, this applies in particular to the erection of barriers or the installation of reinforcing elements by professional civil protection teams, in most countries represented by fire brigades. Even in these cases, however, it is also necessary to train volunteers from endangered places or civic or sports associations, who can significantly strengthen professionals. Training in the preparation of emergency plans and the use of a stakeholder manual are particularly important.

It is especially vital to learn about the possibilities of rescuing buildings or objects affected by a disaster, e.g. flooding with contaminated water. The fateful perception of the disaster by the inhabitants often leads to the feeling of the need for demolitions or removal of the affected objects as waste. Instructions and practical experience in the preservation of mobile cultural heritage help to preserve a considerable volume of family heritage on paper or storage media, which often have a general social value.

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TOPOTHEQUE AND ITS SUITABILITY FOR PARTICIPATORY RECONSTRUCTION

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Definition

A Topotheque is a webbased database that is used for digital storage, indexing and digital publication of historical content. It has a simple structure so that its contents can also be edited by people with no scientific training. With this suitability for pre-scientific source identification, it is used on a broad basis by the public sector, mostly by municipalities, on a citizen science basis with volunteer actors.

Initial objective

The aim of the Topotheque is to quickly locate digital copies based on image content, dating and location. These search functions logically also make it possible to collect digital copies with the same properties, such as finding all images with Ionic capitals. These results can be time-limited and sorted and their location can be further filtered using the map function with a search circle. In addition, a Topotheque acts as a finding aid for the originals, provided their storage location is documented. The input fields correspond to the ISAD-G or Dublin Core archive standard, so that publication can be carried out in accordance with the practices of the archive and internet world. In addition to publishing the content, the Topotheque's main task is digital recording: Although the Topotheque shows entries in reduced file size on the front page, it keeps the saved original files available for those authorized to download. In addition, data sets can remain unpublished for internal research purposes.

The Topotheque for reconstructing knowledge bases

In most cases, a Topotheque is dedicated to a clearly defined topographical topic: the history of a community. This ensures good identification for the population, who are happy to provide private material for "their" Topotheque. With the topic of local history, documentary material from scattered sources, including those who have moved away and tourist visitors, is brought together virtually for electronic searchability. A Topotheque can also be used for collections concerning wide areas. It can be a railway line for which parts of the route can be found in the Topotheque, as can each individual locomotive, regardless of where they were photographed.

The Topotheque has a special application in the participatory reconstruction of destroyed historical centres. A Topotheque was set up and tested very successfully for the model case of Accumoli: <https://accumoli.topoteka.net/>. The Topotheque has proven to be an extremely valuable and useful tool, encouraging not only the local population but also authorities, institutions and external figures with a connection to Accumoli to make their private archives, photographs, films and documents available to the public.

This information is particularly valuable because less prominent but nevertheless architecturally significant buildings, mostly residential buildings, are often not very well documented, especially as they have often undergone changes over time. Photographs in which the buildings usually appear somewhere in the background prove to be important sources of information for the reconstruction of destroyed architectural heritage.

However, it is not only information about the nature of the object that is of particular importance, but also documentation of how the local population interacted with it. How was it used? What functions did it fulfil? What value was attributed to the object?

The value of the Topotheque as a participatory tool in reconstruction

In the context of the reconstruction of historic centres, the Topotheque unfolds a valuable participatory and communal dimension beyond its original purpose of reconstructing information. The active involvement of the public in providing archive materials creates a dynamic that helps to reconstruct historical and cultural identity and collective memories. The collective process of searching for and providing documents, accompanied by dialogue and discussion, also strengthens the intangible dimensions mentioned above.

It is therefore particularly important to accompany this process in a highly professional manner, to offer support in digitising and uploading documents, and to organise regular afternoon sessions for the joint further development of the Topotheque. With the reawakening of collective memory, there is also a growing willingness to become actively involved in the reconstruction process.

Making historical documents from private and public archives available is generating interest in the destroyed site in wider regions. The Topotheque thus offers a valuable source of information for historians, art historians, authors, journalists and even tourism professionals for papers on the destroyed historic centre and the reconstruction process. As mentioned, the Topotheque is also an important source of documents for planners and monument conservators. And, most importantly, it serves as an important source of remembrance for the local population.

Project reference

The ease of use of the Topothek Admin makes it possible to have a large number of people work on reconstruction and reconstruction projects. Particularly with active media support, broad participation can be found, as shown by the successful Topotheques of the municipalities, in which private cultural assets see the light of day for the first time. Crowd sourcing projects that are running well in this way not only provide conservation information but also have a positive effect on people's identification with their hometown. Events and historical projects derived from the virtual collection are beneficial results that can be brought about by a Topotheque. Over 700 communities and institutions in various countries are now using a Topotheques to make the scattered analog historical sources digitally searchable using combined citizen science and crowd sourcing forces.

Box

The Topotheque, initiated by Alexander Schatek, is offered by the ICARUS association (International Centre of Archival Research) based in Vienna. Other platforms from ICARUS are Monasterium.net and Matricula.net, offering for free charters and matrices for research on the internet. Contact: office@topothek.at, www.topothek.at

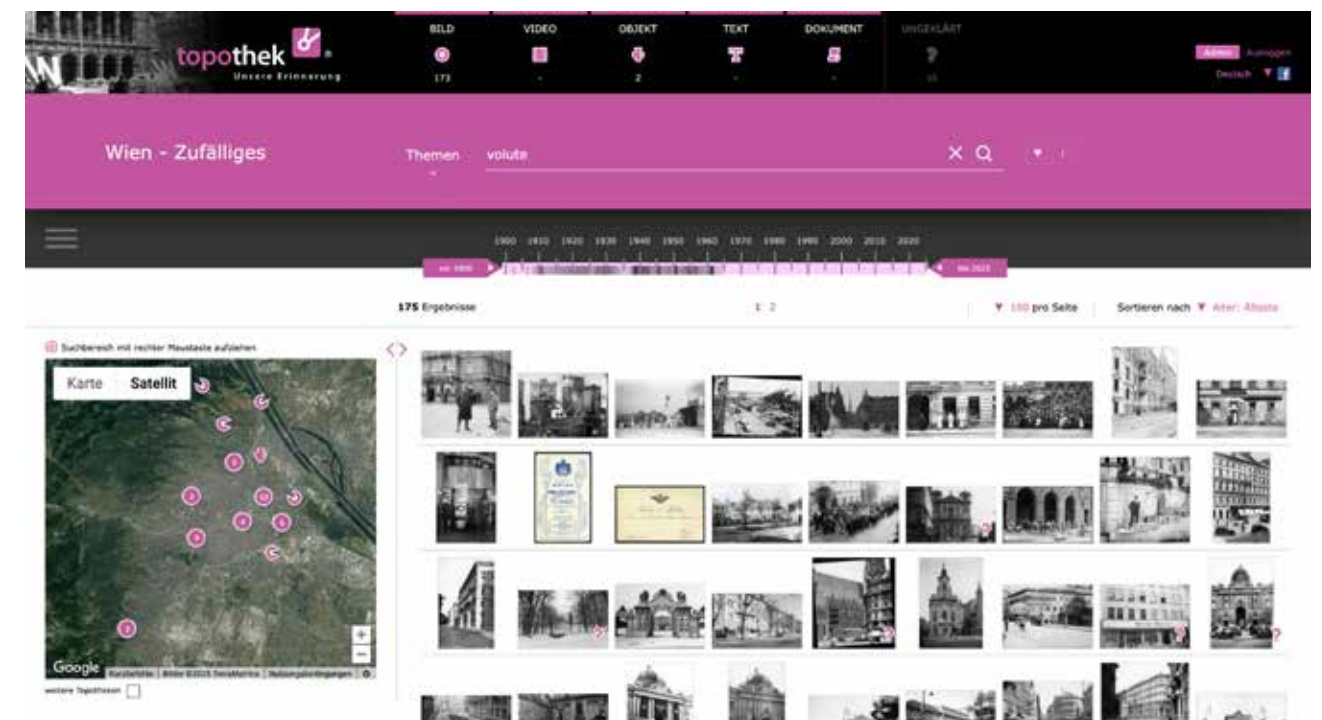


Fig.1 Searching for a construction detail: Volute.

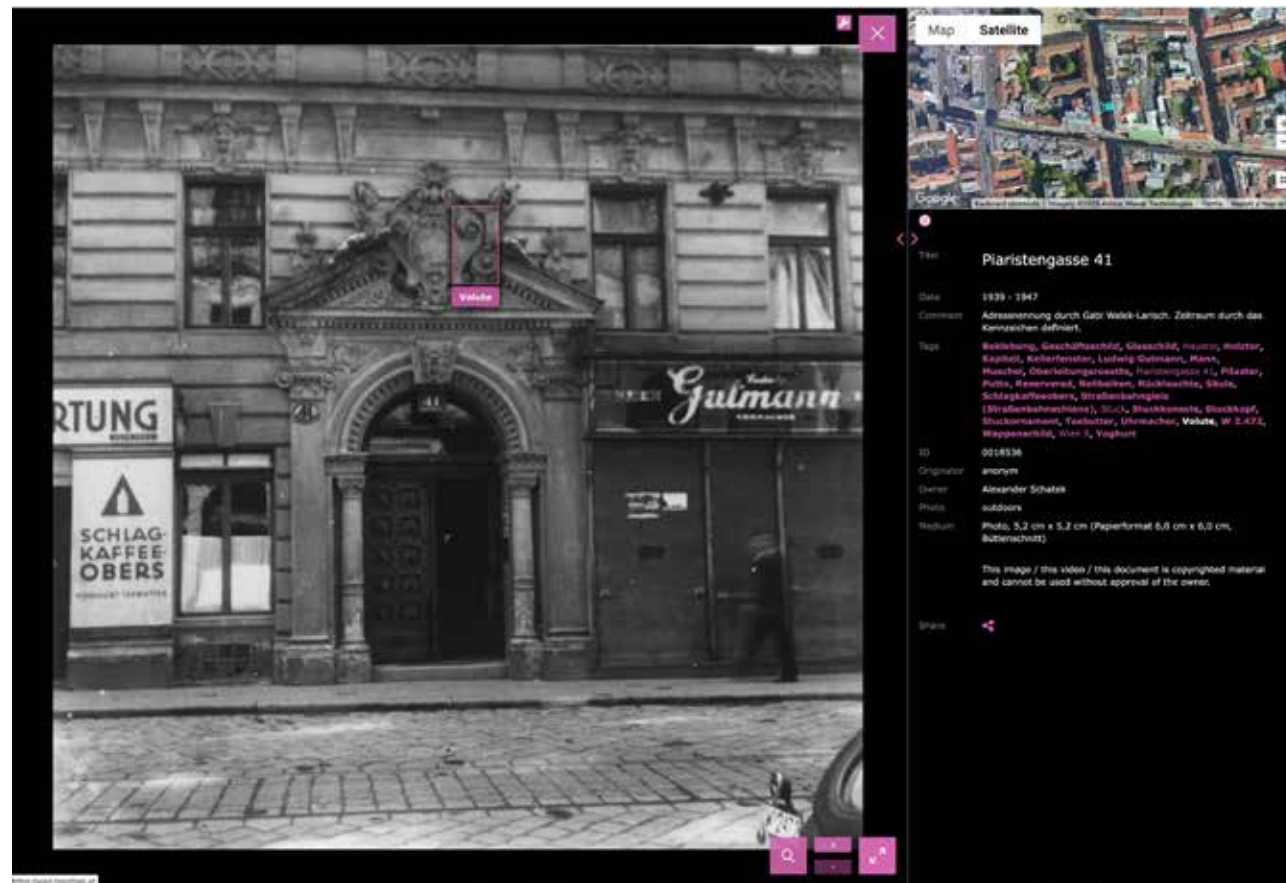
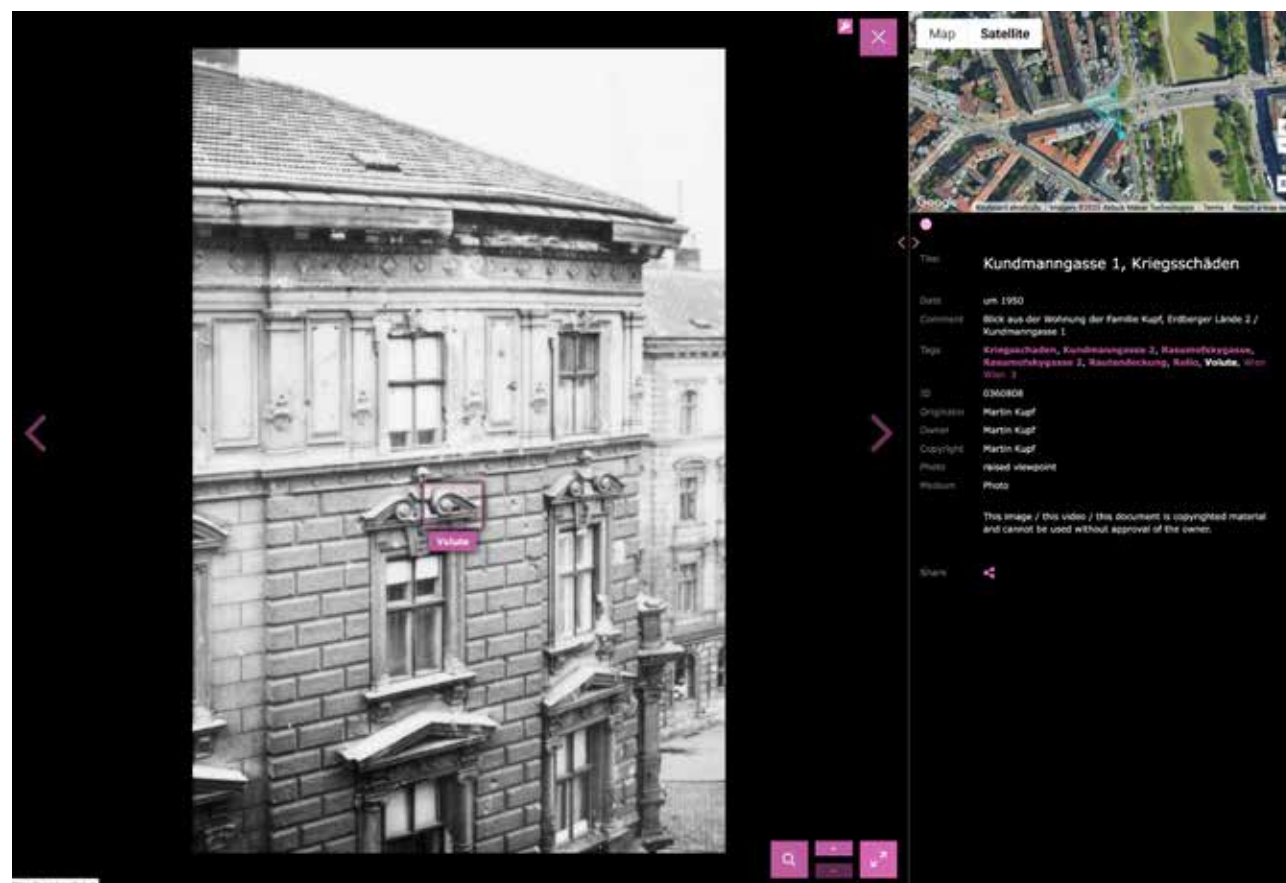


Fig. 2,3 An example of the findings for this search term.

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EMPOWERING COMMUNITIES THROUGH DIGITAL INNOVATION AND SMALL SCALE ARCHITECTURE

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Abstract

The housing crisis that typically results from a disaster is typically addressed through “temporary” prefabricated housing. These structures are usually designed for a short to medium-term lifespan and are often arranged in dormitory-style suburbs that lack basic facilities. When the rebuilding process extends over time, as in many cases, these settlements can lead to a “second emergency” with serious repercussions for community health and cohesion (Ruggiero et al., 2021).

To tackle this issue, some international initiatives have experimented with digital technologies and lightweight building systems and local unskilled labour to create innovative temporary constructions. Notably, the work of Hiroto Kobayashi in the Far East and his “veneer building system” stands out among these studies.

Italy is a seismic country where the “reconstruction” process has historically been contentious, often requiring people to remain in temporary settlements for extended periods. A recent example is the aftermath of the Central Italy earthquake in 2016/2017. Eight years later, only a small percentage of uninhabitable houses have been rebuilt or restored. Some individuals continue to live in provisional settlements, while others have relocated, all facing an uncertain future.

This chapter introduces a methodology for establishing temporary settlements through participatory construction processes for small facilities. This methodology was implemented in a pilot project carried out in collaboration between the Italian University of Camerino and the Japanese Keio University. Two innovative “mobile” pavilions for cultural activities were constructed in Amandola, one of the villages severely affected by the 2016/2017 earthquake. Local students were involved in the project, digital technologies were applied, and the veneer system was tested. This work represents a unique application of digital technologies in the disaster-impacted area of Central Italy, as well as an original implementation of the veneer system.

Introduction: the post-earthquake “Second Emergency Phase” (SEP)

A catastrophe usually devastates houses, and cities, sometimes changing the orographic and morphological conformation of places and the shape of landscapes. It also disrupts the social fabric that binds communities to these environments. The sudden destruction interrupts the intricate relationships between people and their surroundings, transforming familiar spaces into desolate areas. As Guiducci (1975) notes, inhabiting a place involves much more than merely occupying buildings; it encompasses a complex network of human and social connections. Its sudden disruption creates an existential crisis for those affected. Similarly, Oliver-Smith (2003) points out that disasters affect both the material and social dimensions of life, forcing communities into prolonged periods of recovery. Rebuilding homes is essential, but equally important is restoring the social ties and cultural significance that connect people to their living spaces.

In the immediate aftermath of a disaster, institutions trigger procedures focused primarily on saving lives and addressing basic needs. This phase is aimed at restoring physical security and social order. This is the second phase of a process that Drabek (2012), in his disaster management framework, articulates in four key steps: preparedness, response (previously described), recovery, and mitigation. During the response phase, efforts concentrate on rescue operations, securing the environment, and providing temporary shelter. Unfortunately, the urgency of the situations often surpasses the capacity to respond adequately and promptly. As the recovery phase begins, the focus shifts from short-term stabilization to long-term reconstruction. Temporary shelters are gradually replaced by permanent housing, and communities face the challenging task of rebuilding their social and economic structures. This process can take years or even decades, depending on the scale of the disaster and the resources available. In the mitigation phase, communities aim to learn from the disaster to improve preparedness and resilience for future events. Initially, temporary shelters - such as prefabricated tents, caravans, and containers - are rapidly deployed to meet basic needs. These structures are designed for only a few weeks or months of

use. However, as the emergency phase progresses, transitional housing is introduced, offering prefabricated and modular designs that allow for faster construction times. Unfortunately, these options often face issues with adaptability and long-term usability.

Temporary settlements, especially when isolated from urban areas, can create feelings of social and physical disconnection. In Italy, for example, the transition from temporary to permanent housing has historically been slow. Events such as the Belice (1968), Irpinia (1980), and L'Aquila (2009) earthquakes illustrate that temporary settlements can remain in place for decades due to the slow pace of reconstruction. This prolonged delay leads to what Ruggiero et al. (2021) refer to as the Second Emergency Phase (SEP). The SEP marks a critical period that extends beyond the immediate aftermath of the disaster. Communities are often forced to remain in temporary settlements that were never intended for long-term use. These settlements, typically characterized by poor construction quality and lack of infrastructure, can lead to frustration and psychological distress for residents.

Living in precarious conditions for an extended period exacerbates social and psychological impacts, particularly in rural areas where economic and social vulnerabilities are already present. The SEP creates a paradox for the community: while they wait for permanent reconstruction, they continue to live in temporary housing that has become de facto semi-permanent. This prolonged state of uncertainty and instability threatens social cohesion, contributing to isolation and alienation. However, the SEP also presents an opportunity for innovation. Recognizing the protracted nature of this phase opens the possibility of designing more flexible and adaptable solutions that better meet the evolving needs of displaced communities. In this context, design becomes a tool for experimentation and innovation. A participatory approach, where communities engage in decision-making and construction, enables the creation of more responsive and resilient environments.

Goal: designing the transition between “post-disaster” and “reconstruction”

In post-catastrophe management, the design of temporary settlements is often not prioritized as a key issue. Italy serves as a prime example of this trend. Despite being a fragile and highly seismic region, the reconstruction processes in Italy have frequently been slow, with some taking up to 30 years to complete. An exception to this trend is the rapid reconstruction following the Friuli earthquake in 1976. In contrast, significant delays are evident in other situations, such as the Belice reconstruction in Sicily, where some temporary structures (built after the 1968 earthquake) have, over time, become permanent (Bedini & Bronzini, 2018). In cases like this, prolonged stays in inadequately designed temporary housing can impose serious physical and psychological burdens on displaced communities (Cavallari, 2003).

While the urgent need for disaster response often leads to the deployment of temporary shelters, many of these facilities—originally intended for short-term use—become inadequate over time. As a result, residents find themselves in a prolonged state of uncertainty, lacking sufficient long-term housing solutions. This extended stay in transitional housing can weaken the psychological resilience of displaced individuals, especially in rural or socially vulnerable areas (Cavallari, 2003).

Prefabricated housing units and containers, such as Emergency Housing Solutions (SAEs) [1], are often chosen for their speed and cost-effectiveness (Fig.1). However, these units are typically designed for a short lifespan, even though they are frequently used for much longer periods. They are usually arranged in functional layouts similar to military camps, which prioritize logistical efficiency over the long-term social and community needs of the residents. Consequently, they often fail to provide acceptable living conditions over time, leading to a decline in social cohesion within these temporary settlements

This situation highlights a significant flaw in emergency housing policies: they often overlook the changing needs of long-term displaced populations by focusing primarily on logistical efficiency. Temporary shelters should be designed for adaptability and flexibility. Without these features, temporary shelters risk becoming inadequate, failing to provide the decent living conditions needed to foster a sense of community (Di Bucci et al., 2023).

[1] In response to the seismic events that affected Central Italy in 2016 and 2017, the Italian Civil Protection Department implemented a series of emergency housing measures known as "Soluzioni Abitative di Emergenza" (SAE), or Emergency Housing Solutions. These prefabricated timber structures were specifically designed for rapid assembly and intended to offer durable accommodation for several years. The SAE units come in three standardized sizes—40, 60, and 80 square meters—to accommodate the diverse needs of affected families. Constructed using Platform Frame technology, these structures ensure swift deployment while adhering to strict seismic safety standards.

Otherwise, contemporary architectural approaches increasingly acknowledge temporariness as a dynamic and evolving condition. These methods emphasize flexibility and adaptability, enabling both temporary and permanent housing to better meet the changing needs of residents while enhancing social and psychological well-being. This focus is especially vital in disaster recovery, where the reconstruction process often takes longer than initially planned (Arnetoli & Bologna, 2023).

A major shortcoming of previous post-disaster housing solutions has been the lack of community involvement in the design and construction processes. By involving residents in co-design and co-construction, we can foster a sense of ownership and control over the reconstruction process, which empowers communities. This participatory approach has been shown to enhance the psychological well-being of displaced populations by aligning housing solutions with their specific needs and preferences. Research indicates that solutions co-created with the community are often more sustainable, better integrated into the local environment, and more acceptable to residents (Marchetti et al., 2000).

The Second Emergency Phase (SEP) represents a critical opportunity for design innovation. Given the uncertainty of reconstruction timelines and the increasing obsolescence of temporary housing, design strategies must prioritize flexibility, reversibility, and adaptability to effectively meet the immediate and long-term needs of displaced communities (Perriccioli, 2016).

Temporary housing solutions, such as those implemented in the SAE settlements in Central Italy, highlight the limitations of traditional designs that often fail to address long-term sustainability and social integration. Therefore, a shift toward adaptive design is essential to ensure that temporary housing evolves in response to changing community needs while supporting the social and psychological well-being of residents.

By recognizing the potential of flexible, high-quality temporary structures that connect emergency response with reconstruction, we can create more resilient communities. Engaging in participatory design allows local residents to actively shape their own recovery, fostering a sense of agency and belonging that is crucial for their long-term psychological recovery.



Fig. 1 Commercial structures in a S.A.E. temporary settlements. (image by the Authors)

Method: participatory process through digital innovation

In Europe and, more broadly, in all industrialized contexts, most production processes have undergone a significant transformation over the past 20 years. This change is largely due to what is known as the fourth industrial revolution, or the "digital revolution." Digital manufacturing encompasses a complex system of innovative technologies that are giving rise to new models, systems, and paradigms for producing physical objects, all of which have substantial social, economic, and environmental implications. Key technologies involved in this transformation include Parametric and Generative Design, Building Information Modelling, Digital Twin technology, Digital Design Platforms, and various technologies related to Computer Numerical Control (CNC) machines. Additionally, advancements in 3D Printing, Robotic Manufacturing, and technologies associated with Extended Reality play crucial roles. These innovations not only revolutionize the construction sector by altering traditional design paradigms and the management of industrialized construction processes, but they also serve as important drivers for research and experimentation in bottom-up construction architecture. This impact is particularly notable in the fields of temporary and small-scale architecture

The integration of digital technologies has greatly enhanced participatory construction methods in various contexts. A notable example is the Wiki House project, launched in 2011 by Alastair Parvin and Nick Ierodiaconou. This initiative marks a significant milestone in employing digital processes for participatory construction. As Mario Carpo describes it in the context of the “second digital turn”, Wiki House showcases the transition from mass customization to user-centric, distributed design and fabrication methods (Carpo, 2017). As an open-source project, Wiki House democratizes the building design and construction process by providing freely accessible design files. These files enable computer numerical control (CNC) fabrication of modular components from materials such as plywood. These components can be assembled with minimal training, allowing individuals and communities to efficiently and affordably construct sustainable dwellings. Additionally, the open-source nature of the design files permits customization and adaptation to meet specific community or individual needs (Wiki House, n.d.).

In post-disaster situations, participatory construction methods are crucial for addressing the urgent need for housing and community rebuilding. The Veneer House project, created by architect Hiroto Kobayashi after the 2011 Tohoku Earthquake and Tsunami, showcases the use of CNC fabrication for quick and cost-effective reconstruction (Fig. 2a; 2b). This project employs CNC-routed plywood components, allowing unskilled laborers to assemble the structures rapidly using materials that are readily available. This method not only enables efficient rebuilding but also promotes community involvement and empowerment, allowing affected individuals to play an active role in the reconstruction process. (Kobayashi, 2017).



Fig. 2a Participatory construction of the Maeamihama Veneer House. (image by Hiroto Kobayashi).



Fig. 2b Convivial moment in the Maeamihama Veneer House (image by Hiroto Kobayashi).

The Veneer House system focuses on simplicity and adaptability, facilitating the construction of durable shelters without the need for specialized tools or expertise. By utilizing digital fabrication technologies, the project guarantees precise production of components, leading to structures that combine ease of assembly with high architectural and building performance standards. The system's application extends beyond Japan to countries like Italy, where the Accupoli project was developed in response to the 2016 earthquake that severely damaged Accumoli, in the sub-Appenine area of Central Italy. This collaboration between Politecnico di Torino and Kobayashi's laboratory at Keio University adapted the Veneer House construction system to the local context, resulting in Italy's first self-supporting plywood structure. Accupoli now serves as a multifunctional space for community use, demonstrating the system's versatility and cultural sensitivity.

These projects showcase the transformative potential of digital technologies in participatory architecture. By integrating digital fabrication with open-source collaboration, they empower communities to take an active role in the construction process, which is essential for the social and psychological recovery of affected populations. In post-disaster reconstruction, these methodologies not only accelerate rebuilding efforts but also foster resilience, inclusivity, and sustainability in the built environment (Rawat et al., 2024).

Tools: digital fabrication as a “trigger” for participatory design

Digital fabrication technologies, such as CNC milling and 3D printing, have become essential in modern construction processes, providing unmatched advantages in precision, scalability, and adaptability [2]. These technologies enable the rapid production of modular building components that can be easily customized to meet specific project requirements. This flexibility is particularly important in participatory design contexts, where community involvement in co-design and assembly is crucial. By simplifying complex fabrication tasks, digital tools allow individuals with limited technical skills to contribute meaningfully to construction efforts, promoting inclusivity and community engagement.

Advancements in digital fabrication technologies, particularly in CNC milling, have greatly expanded the potential for processing materials like timber. These advancements have made timber an attractive alternative to traditional construction materials (Menges, Schwinn, & Krieg, 2016), especially for small-scale projects and temporary structures. Its adaptability allows for the exploration of new possibilities in design and construction. Timber is increasingly recognized for its sustainability and versatility, owing to its workability, low carbon footprint, and wide availability. It is easily accessible and simple to process using CNC milling and standard tools, which enables communities to engage in co-design and co-construction, even without specialized skills.

CNC milling plays a crucial role in automating the precise cutting and shaping of timber based on digital designs (Fig. 3). This technology not only enhances the speed and accuracy of production but also facilitates real-time prototyping. Architects and engineers can quickly create physical models, allowing for design refinement and serving as instructional tools for unskilled labor. These prototypes guide workers through the construction process, reducing training time and ensuring efficient project completion.

In the context of post-disaster reconstruction, CNC milling proves to be especially valuable. It allows for the rapid production of modular and easily assembled components, which is essential when a displaced workforce with limited construction experience is available. Prefabricated units can be produced at scale to meet the urgent demand for temporary housing while adhering to safety and durability standards. For example, the recovery effort following the Hiroto Kobayashi earthquake demonstrated how CNC milling can produce modular constructions tailored to specific regional needs.

[2] In contemporary construction, digital fabrication technologies have fundamentally transformed architectural design and production. 3D printing, or additive manufacturing, allows for the creation of complex geometries through layer-by-layer material deposition, facilitating rapid prototyping and extensive customization. CNC milling, a subtractive process, uses computer-controlled machining tools to carve precise geometrical shapes from various materials such as wood, metal, and plastic. Laser cutting and engraving technology provide accurate cutting and etching of materials, making them invaluable for intricate architectural details. Robotic arm fabrication combines advanced robotics with various fabrication tools, significantly improving efficiency and versatility in constructing complex structures and performing repetitive tasks. Additionally, automated brick-laying technology employs robotic systems to lay bricks, greatly accelerating construction speeds while reducing labor costs and maintaining high-quality outputs. For a comprehensive discussion of these technologies and their applications in architecture, refer to Kolarevic (2004).

CNC milling supports generative design by using algorithms to optimize structures based on local environmental factors, such as climate and available materials. Rapid prototyping and feedback integration ensure that the final designs effectively meet the needs of the affected population. Furthermore, simplified assembly processes enable communities to participate directly in rebuilding their homes and public spaces, even without prior technical experience. This involvement is crucial in post-disaster recovery, as it promotes social cohesion and fosters psychological resilience by restoring a sense of control and collective achievement.



Fig. 3 - CNC Milling Machine. (image by the Authors)

Experimentation: a partnership between Saad Unicam and Keio University in Central Italy

In 2019, the School of Architecture and Design (SAAD) at the University of Camerino and Keio University in Tokyo initiated a collaborative project aimed at addressing the needs of communities affected by the seismic events in Central Italy from 2016 to 2017. Their shared objective was to develop innovative emergency structures that could be quickly assembled and adapted to local requirements. The project utilized advanced digital fabrication techniques to design small-scale pavilions, which included a library and an exhibition space. By incorporating modern technologies, the focus was on streamlining the construction process while ensuring the active participation of the community. This collaboration was organized into three essential phases:

1. Talk/Listen: this phase involved gathering the needs and concerns of the community.
2. Design/Produce: in this stage, the team engaged in digital co-design and rapid prototyping of the structures
3. . Assemble/Use: here, local residents participated in building the pavilions, fostering a sense of ownership and collective effort within the community.

Talk/Listen: Engaging the Community to Identify Needs and Preferences

The first phase of the collaboration was marked by extensive dialogue with both students and the local community of Amandola, a town significantly affected by the earthquakes of 2016-17. This step was crucial in establishing a clear understanding of the community’s needs and the broader challenges associated with post-disaster recovery.

Local municipal authorities were approached first to introduce the project and ensure its goals were aligned with the town's needs. This resulted in an agreement between the University of Camerino and the Amandola municipality, which facilitated the implementation of the project. Following this, a public conference titled AAT (Amandola, Ascoli, Tokyo): Italy Meets Japan" was organized, inviting local residents, stakeholders, and international experts to participate. These discussions provided valuable insights into the psychological, social, and physical needs of the population following the disaster, ensuring that the project was firmly rooted in the community’s actual conditions.

Engagement with the students, many of whom came from the affected regions, further strengthened this phase. Their involvement was not merely academic but deeply personal, as they brought their firsthand experiences and a genuine desire to contribute to the reconstruction efforts. Both Italian and Japanese students underwent training in generative and computational design, as well as digital manufacturing processes, preparing them for the subsequent design phases.

Design/Produce: using digital tools for co-design and rapid prototyping

The design phase was a collaborative, digitally-driven effort that united students from SAAD and Keio University, guided by Professors Hiroto Kobayashi, Akira Suzuki, and Roberto Ruggiero. The goal was to develop small-scale, temporary pavilions that could be quickly assembled and disassembled, providing essential services to the community during the Second Emergency Phase (SEP). A key feature of the design was the reinterpretation of Professor Kobayashi's Veneer system, a construction technique that utilizes interlocking timber panels, thereby eliminating the need for metal joints. This method not only simplifies assembly but also results in lightweight, flexible structures that are easy to disassemble, making them ideal for post-disaster scenarios.

Digital tools played a significant role in this phase. Parametric 3D models were used to manage crucial design variables such as dimensions, material thickness, and transportability. Generative design techniques enabled the team to explore various design options while optimizing for structural integrity, ease of assembly, and cost-efficiency. Prototypes were developed at different scales, starting with hand-made maquettes and progressing to 1:10 scale models created with laser cutters (Fig.4a;4b). These models helped to refine the design and ensured that the structures would be practical for production and assembly in real-world conditions.

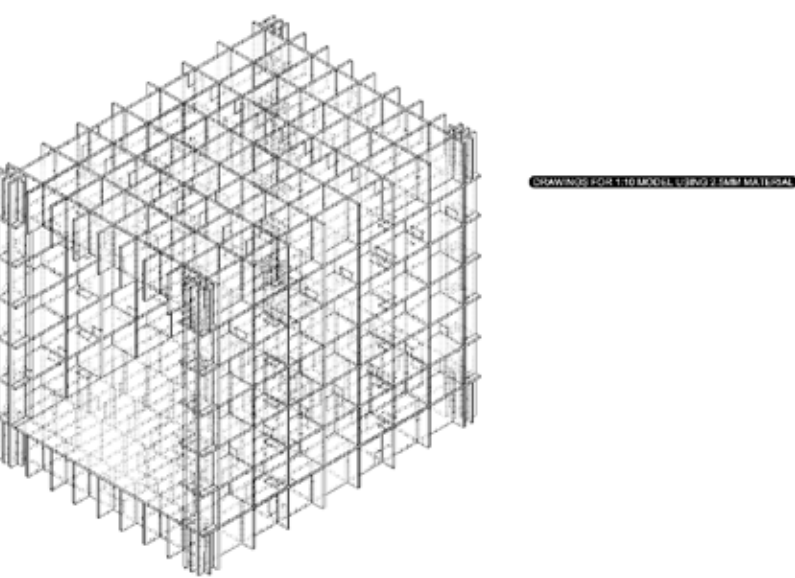


Fig. 4a Pavilion 3d model for prototyping. (image by the Authors)



Fig. 4b 1:10 scale model study. (image by the Authors)

The CAD-CAM process significantly improved the production phase by enabling precise CNC milling of wooden components. The SAAD PrototypeLab played a crucial role in this process, where marine plywood and fir beams were utilized to create the final building elements. The use of Rhino CAM software allowed for the conversion of digital designs into machine-readable code for the CNC machines, ensuring a smooth transition from design to production (Fig. 5).



Fig. 5 Nested pieces in the plywood board prepared for cutting. (Image by the Authors).

Assemble/Use: community participation in assembly

The final phase concentrated on the assembly, which took place in Amandola’s historic square and later at SAAD in Ascoli Piceno. The assembly process was designed to be accessible to unskilled labor, allowing local residents to actively participate (Fig. 6a; 6b). This was essential for fostering a sense of ownership and community involvement in the post-disaster recovery effort.

The design employed the Kobayashi veneer system, which enabled the structures to be assembled without screws or metal joints, relying instead on the interlocking of wooden panels. This simplified approach made it easy for local citizens to assist the students in erecting the pavilions. In fact, the entire assembly process took only four hours, demonstrating the practicality and efficiency of the design.

The construction of these structures alongside students also offered psychological benefits for local residents. It provided them with a hands-on opportunity to actively contribute to their own recovery, helping to alleviate feelings of helplessness and frustration that arose from long-term displacement. By engaging in both the co-design and construction processes, the community could observe tangible progress in their environment, which not only helped rebuild physical spaces but also restored the social cohesion that had been fractured by the disaster.

This practical experience echoed traditional Japanese construction methods, which emphasize simple, reversible building techniques. The cultural exchange between the Italian and Japanese teams further enriched the project, leading to an innovative and adaptable approach to emergency architecture that could serve as a model for future post-disaster interventions.

After the pavilions were assembled, a book presentation and community gathering took place, uniting students and residents of Amandola (Fig. 7). This event underscored the transformative potential of small-scale architectural interventions in post-disaster recovery. Beyond providing physical spaces for cultural exchange and interaction, the pavilions fostered a sense of ownership among the community. By actively

involving local residents in both the design and assembly processes, the project not only created functional structures but also empowered the community to participate in their own recovery. This participatory approach reinforced the idea that temporary architecture can play a crucial role in repairing the social fabric, fostering resilience, and restoring a sense of belonging to communities disrupted by natural disasters.



Fig. 6a Local students assembling the pavilion in Amandola. (image by the Authors)



Fig. 6b Japanese students assembling the pavilion in Amandola. (image by the Authors)



Fig. 7 Book presentation in Amandola. (image by the Authors)

Conclusion

The intersection of digital technologies and participatory construction offers a transformative approach to the complex challenges of post-disaster recovery. By integrating digital fabrication, community engagement, and innovative architectural strategies, temporary housing solutions can effectively address the long-term social, psychological, and economic impacts of disasters. Projects like the Veneer House and Accupoli demonstrate how adaptive, modular designs, combined with participatory processes, can support both immediate relief and sustainable recovery. These initiatives foster a sense of empowerment and ownership within affected communities.

The use of digital tools such as CNC milling and parametric design facilitates the rapid and precise production of modular building components. These technologies democratize the construction process, decreasing reliance on specialized labor and enabling displaced populations to actively participate in their recovery. This involvement is not just a technical accomplishment; it also serves as a psychological intervention, countering the feelings of alienation and disconnection that often arise during the extended Second Emergency Phase. By bridging the gap between emergency response and reconstruction, digital innovation can transform temporary settlements from mere necessities into vibrant spaces of opportunity, community, and resilience (**Fig.8**).



Fig. 8 Think, Make, Create and, of course, Participate represent the guiding principles of our methodological approach. (image by the Authors)

The collaboration between SAAD and Keio University in Amandola underscores the importance of integrating cultural sensitivity, local expertise, and community participation in architectural interventions. The resulting pavilions, lightweight yet durable, demonstrate how design can be a vehicle for both physical reconstruction and the restoration of social cohesion. These small-scale projects reveal that temporary structures can offer more than shelter - they can be catalysts for cultural expression, communal interaction, and the rebuilding of a shared sense of place.

Future applications of such methodologies must continue to evolve, prioritizing adaptability, sustainability, and inclusivity. By recognizing temporariness as a dynamic and transitional state rather than a fixed limitation, architects and designers can craft solutions that address both the immediate needs and the long-term aspirations of disaster-affected populations. Through participatory digital innovation, the architecture of disaster recovery is reimagined - not merely as a response to crisis but as a proactive framework for resilience, dignity, and hope in the face of uncertainty.

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METHODS FOR AN ENERGY-EFFICIENT RECONSTRUCTION

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Abstract

This paper presents a methodology for the energy-efficient reconstruction of settlements damaged by natural disasters, focusing on improving the quality of living in terms of energy efficiency, supply security and comfort. Achieving these conditions, as well as reactivating economic circuits based on local resources enhancement, is strategic for a return to inhabit these territories affected by depopulation, and contributes to meet European goals of decarbonization and energy independence. A structured sequential approach is presented, encompassing multiple scales of analysis with the aim of supporting designers and planners to develop effective and efficient reconstruction strategies in harmonious alignment with the potential of the context, for a sustainable and resilient future. The methodology integrates environmental context analysis, like climate and urban analysis and assessment of local renewable resources, and analysis of historic buildings stock, their construction features and energy performances. Intervention strategies are explored for improving energy efficiency while simultaneously respecting historical architectural values. Moreover, the possibility of achieving energy self-sufficiency is highlighted, through technical feasibility assessment of new supply systems based on the use of local renewable resources, showing a circular model that benefits the local economy and a proposal for energy collective self-consumption, complying European directives. Software tools are presented and documentary references from literature and institutions validate the methodology and make it replicable. The paper applies this methodology to the case study of the village of Terracino, in Accumoli municipality, which was affected by the 2016 earthquake. The research concludes that the proposed methodology can serve as a model for similar contexts, highlighting the opportunity to transform post-disaster crises into opportunities for sustainable development and social-economic revival.

Energy transition as a driver for revitalizing the post-disaster territory

Energy efficiency in buildings, reducing greenhouse gas emissions linked to fossil fuel energy consumption, and increasing renewable energy production are urgent objectives in Europe, addressing not only environmental but also socio-economic concerns. These goals contribute to mitigating the global natural disaster of climate change and aim to achieve energy supply independence from foreign countries.

In Europe, buildings account for 40% of final energy consumption and 36% of emissions related to energy demand. 75% of the building stock is still inefficient, with only 1% undergoing significant energy renovations. Furthermore, 39% of heating needs are still met by natural gas (European Parliament and the Council of the European Union, 2024).

The European Commission has set the goal of achieving climate neutrality by 2050 with the Green Deal and has defined a series of initiatives under the "Fit for 55%" package to support the intermediate target of a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels. This framework establishes new sector-specific directives and an approach that ensures social fairness and economic competitiveness in the transition to a reformed future system (European Commission, 2021).

Regarding energy efficiency, Directive 2024/1275 mandates that by 2030, at least 16% of the most energy-intensive existing non-residential buildings must be renovated, and there must be a general reduction of 16% in average primary energy consumption for the entire residential sector. (European Parliament and the Council of the European Union, 2024) (Fig. 1). Concerning energy supply, Directive 2023/2413 promotes the use of renewable energy, setting a community target of 49% coverage in final energy consumption for buildings sector. It also supports bottom-up participatory forms of energy production and sharing at the local level, as previously introduced by Directive 2018/2001, to maximize collective self-consumption and combat energy poverty (European Parliament and the Council of the European Union, 2023).

In Italy, in 2021, 44% of final energy consumption was attributable to the civil sector, responsible for 26% of non-ETS sector emissions. Approximately one-third of civil sector consumption is due to the residential

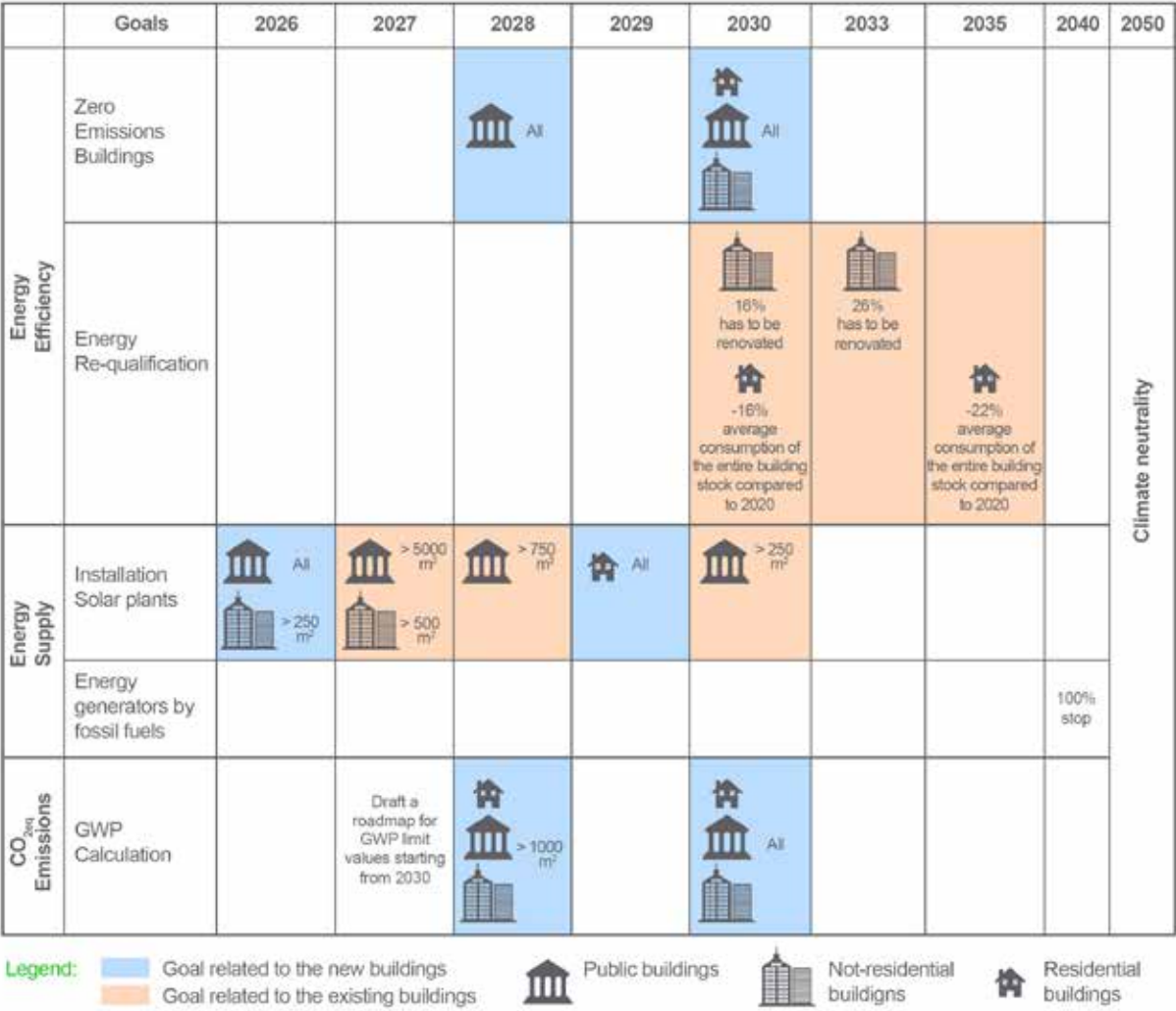


Fig. 1 Goals of the Directive 2024/1275 for the roadmap to the climate neutrality by 2050 (European Parliament and the Council of the European Union, 2024)

component, characterized by over 60% of buildings constructed before the first energy-saving law, Law 373/1976. The Piano Nazionale Integrato per l’Energia e il Clima sets targets for 2030, including a 43% reduction in primary energy needs by 2030 compared to the 2007 scenario, a 40% share of renewable energy sources in gross final consumption, and a 40% reduction in emissions compared to 2005 levels in the non-ETS sector (Ministero dell’Ambiente e della Sicurezza Energetica, 2024).

The forced condition of rebuilding damaged buildings in the aftermath of natural disasters accelerates, albeit coercively, the transition to more energy-efficient systems. It presents an opportunity to rethink construction technologies for living environments with the goal of achieving better indoor comfort and introducing innovative, sustainable energy supply systems. This occurs within a complex and sometimes complicated debate between respecting the historical identity of existing or pre-existing heritage and the drive towards innovation required by contemporary living needs, which shape new identity forms for communities linked to new values and habits.

There are situations where the traumatic impact of a natural disaster exacerbates the wounds of a territory already marked by endemic socio-economic difficulties. This is the case for small settlements within the earthquake crater that affected the internal areas of the Central Italian Apennines in 2016. Italy is composed of 70% Small Municipalities with fewer than 5,000 inhabitants (Istat, 2024), and nearly 73% of these are affected by a negative demographic trend (Associazione Nazionale Comuni Italiani, 2019) (Fig. 2). Among the 140 municipalities involved in the seismic crater area (Presidente della Repubblica, 2016), 85% are Small Municipalities, with about half having fewer than 1,000 inhabitants, and over 95% are experiencing depopulation (Fig. 3).Data on the long-term negative demographic trend highlight the lack of socio-economic competitiveness of these territories and indicate the difficult challenges of reconstructing and revitalizing an area already struggling before the calamity

Energy-efficient reconstruction and the reactivation of economic circuits based on local resource enhancement provide the conditions for a return to permanence in these territories, and including the goal of energy supply is strategic for increasing supply security and reducing costs.

The entire seismic crater falls within rural mountain areas, like 71% of Italy's Small Municipalities (Istat, 2024). In Italy, the strong reduction in agro-silvo-pastoral activities over the last century has led to an increase in forested areas due to the spontaneous recolonization of abandoned lands (Ministero delle Politiche Agricole Alimentari e Forestali, 2012). Forested area covers approximately 11 million hectares, over one-third of the national territory (Gasparini et al., 2022) and has shown continuous growth, with an overall increase of 32% since 1985 (Fig. 4). However, only about 15% of forested areas are subject to planning and management (Food and Agriculture Organization of the United Nations, 2020).

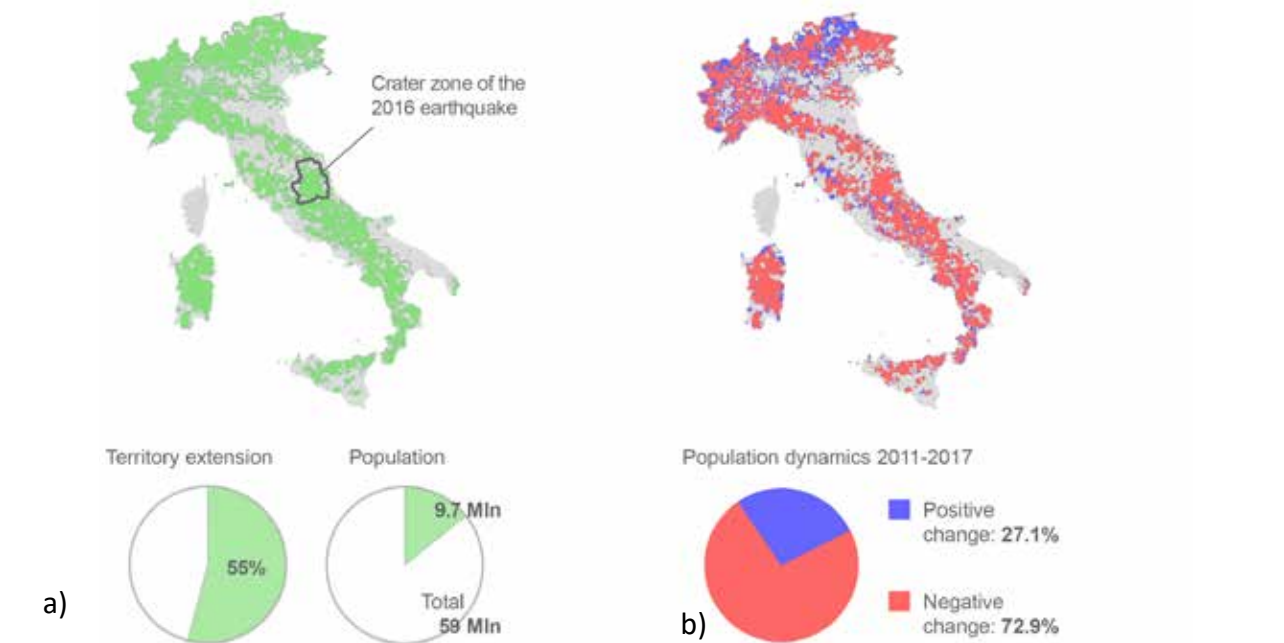


Fig. 2 (a) Small Municipalities with less than 5000 residents in Italy (Istat, 2024). (b) Demographic Trends of Small Municipalities in Italy (Associazione Nazionale Comuni Italiani, 2019)

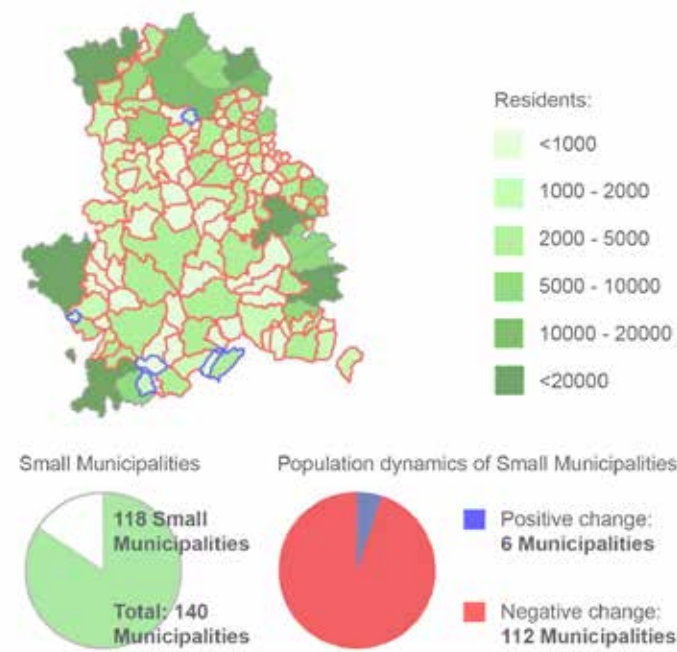


Fig. 3 Population of Municipalities and Demographic Trends in the crater zone of 2016 (Associazione Nazionale Comuni Italiani, 2019; Presidente della Repubblica, 2016).

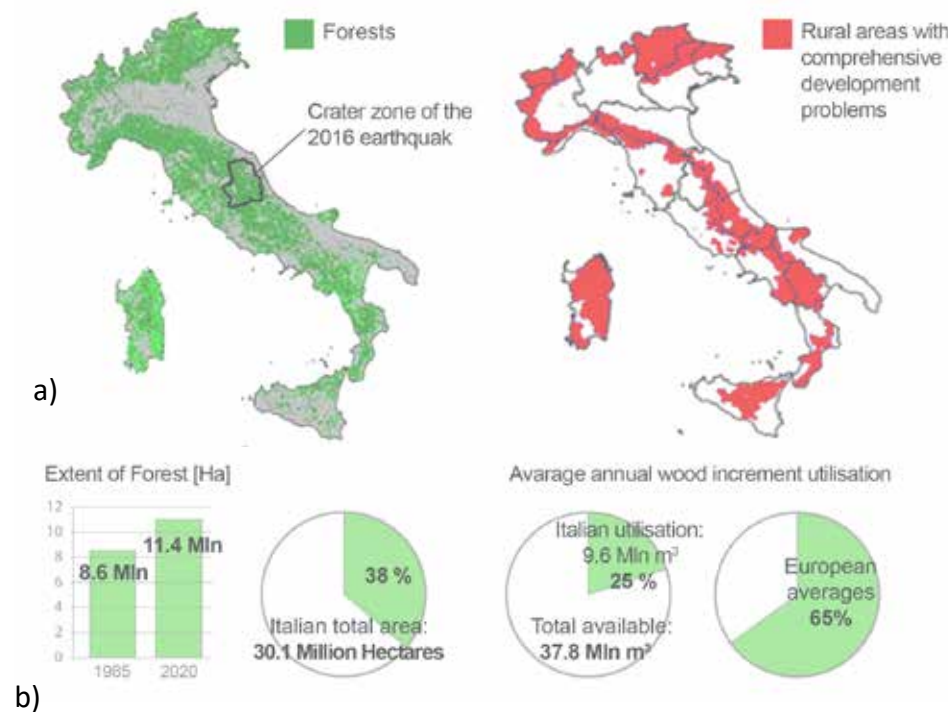


Fig. 4 (a): Comparison between the forestry areas (Gasparini et al., 2022) and the rural areas with comprehensive development problems (Rete Rurale Nazionale, 2014) (b) Data on the extent of forest areas and the wood increment utilization in Italy and comparison with the European average annual wood increment utilization (Eurostat, 2021; Food and Agriculture Organization of the United Nations, 2020; Gasparini et al., 2022).

The Strategia Forestale Nazionale aims to promote sustainable active forest management practices to protect the mountain economy and ensure services for preventing natural and anthropic risks, hydrogeological defense, and fire protection (Ministero dell'Agricoltura, della Sovranità Alimentare e delle Foreste, 2022). The PNIEC supports the recovery and enhancement of forest materials and the creation of supply chains for the collection and transformation of forest products into useful fuels for district heating (Ministero dell'Ambiente e della Sicurezza Energetica, 2024). The mentioned Directive 2023/2413, in supporting bioenergy, mandates circular use of wood biomass, where energy purposes must be considered as a form of recovery after other economic and production cycles (European Parliament and the Council of the European Union, 2023), thus extending the possibilities for wood-related supply chains to the benefit of communities.

In conclusion, the experience described below is based on the idea that aiming for energy efficiency in post-disaster reconstruction practices not only complies with legal requirements and envisions a scenario of improved living comfort in settlements compared to the pre-event conditions but it can also support the process of socio-economic revitalization (Fig. 5).



Fig. 5 - Graphical concept of the methodology for energy-efficient reconstruction in the mountain areas of the crater zone of 2016 earthquake.

A replicable methodology for the energy-efficient reconstruction of damaged settlements

The objective of the presented work is to develop a methodology to support the design of interventions for the reconstruction of settlements damaged by natural disasters, with the aim of improving the quality of living in terms of energy efficiency and comfort. This methodology organizes, in a sequential manner and across different scales, the planning operations for energy efficiency and supply strategies at a systemic level, as well as the design actions aimed at specific technological interventions. It also identifies the available prescriptive-legislative and operational-practical tools that designers can reference. The methodology is applied to a case study that serves as an example with replicable value for use in similar contexts.

Within this framework, the following objectives were set:

1. Analysing and understanding the environmental context in which the work takes place, to ensure that the reconstruction strategy aligns with the climatic characteristics and available resources in the area, in order to utilize them effectively.
2. Understanding the energy performance of historic buildings and identifying energy efficiency interventions, to reduce energy needs and improve the microclimate for indoor comfort.
3. Assessing the technical feasibility of energy self-sufficiency through the use of local resources, to achieve an optimized closed circular system in which energy needs are fully balanced by short supply chain procurement.

From understanding the environmental context to assessing the feasibility of energy self-sufficiency

The methodology begins with the study and understanding of the climatic and environmental context of the settlements under consideration, as well as the local natural resources available for energy supply. It then progresses to the analysis of construction technologies and the energy performance of existing and pre-existing historic buildings. Following recommendations from literature or guidelines issued by institutions for the preservation of historic buildings, it identifies and suggests strategies and actions for improving energy performance, simulates the expected new energy needs, and assesses the feasibility of using new technologies for energy services powered by local resources.

The structure of the developed methodology is outlined below:

1. Climatic analysis, to understand the local context in terms of solar radiation, air temperature and humidity, and prevailing winds.
2. Urban analysis, to evaluate the morphology of the built environment and the interactions in terms of mutual shading.
3. Identification of passive strategies, to improve indoor comfort conditions in buildings.
4. Analysis of local renewable energy resources, to quantify the availability of energy supply.
5. Analysis of the building stock and energy needs in the current state, to assess the performance level in the existing condition.
6. Identification of intervention strategies and technical-design solutions at the building scale, to improve energy performance and indoor comfort.
7. Estimation of energy needs in the project state, to assess the achieved performance level.
8. Technical feasibility assessment of new supply systems for energy self-sufficiency, to use local renewable resources for the newly retrofitted settlements.

The integration of planning tools and digital simulation software for analysis and identification of interventions

The methodology integrates a variety of tools due to its complexity, as it involves different topics and is based on processing data sourced from sector-specific references. Following the key points of the methodology as outlined in the previous paragraph, the tools utilized are introduced, and their results will be analyzed in the next section:

1. Climatic analysis.

For this analysis, Meteonorm 8 software was used, which contains a database of hourly climatic data from existing weather stations, averaged over twenty-year observation periods, and appropriately interpolated to cover any requested location.

2. Urban analysis.

This analysis requires the use of 3D modeling software integrated with solar path simulation at the desired latitude, allowing for the assessment of shading among building volumes, whether existing or to be reconstructed, and exposure to solar radiation at any time of the year. In this case, Rhinoceros software was used.

3. Identification of passive strategies.

For this task, software capable of analyzing the psychrometric chart of humid air is used, which identifies the thermohygrometric comfort conditions of spaces based on external air temperature and humidity data. These tools allow for the evaluation of passive strategies at the building level by providing an estimate of the modification of indoor comfort conditions achievable through their application. In this case, Weather Tool software was used.

4. Analysis of local renewable energy resources.

This work focused on the availability of solar radiation and woody biomass, considered within a circular supply chain that uses sustainably harvestable material.

4.1. To quantify the availability of solar radiation incident on vertical and inclined surfaces, useful for passive architectural design choices or the installation of energy self-production devices, Ecotect simulation software was used.

4.2. For the survey of sustainably harvestable woody biomass, GIS software was used to process maps from planning tools such as the Carta forestale regionale su base tipologica to quantify the extent and type of forested areas (Regione Lazio, 2021), the Piani di Gestione e Assestamento Forestale that municipal offices should adopt to quantify annual wood growth, estimate the availability of material for sustainable harvesting, and plan cuts (Ufficio Tecnico del Comune di Accumoli, 2014), and the Carta regionale delle Acclività useful for excluding forested areas with difficult access (Dipartimento per gli Affari Regionali e le Autonomie, 2015).

5. Analysis of the building stock and energy needs in the current state.

For this analysis, technological tools for direct non-invasive diagnostic surveys, technical cadastral documentation, and models available in the literature for comparative uses are suggested:

5.1. Infrared thermography, which allows for the identification of thermal bridges, thermal characteristics, and material discontinuities in construction systems, by detecting the surface temperature distribution on walls.

5.2. Cadastral tables for identifying the building stock in terms of habitable surfaces. This methodology focuses on the residential sector.

5.3. The matrix developed by the Politecnico di Torino within the European TABULA project (Corrado et al., 2014), which assigns an annual specific thermal consumption value for each model building representative of a specific residential typology and a specific construction period in climate zone E.

5.4. The Micene study conducted by the Politecnico di Milano (Di Andrea & Danese, 2004), which monitored 110 homes and cataloged annual electrical consumption based on the extent of habitable surfaces.

6. Identification of intervention strategies and technical-design solutions at the building scale.

The *Linee di indirizzo per il miglioramento dell'efficienza energetica del patrimonio culturale*, drafted by the Ministry of Culture (Soprintendenza Archeologia, Belle Arti e Paesaggio per l'area Metropolitana di Venezia e le Province di Belluno, Padova e Treviso, 2015), were taken as a reference, which contains recommendations for the protection of historical values in intervention operations. The design actions were validated with the ANIT PAN 7.0 energy calculation software, which analyzes thermal performance and verifies compliance with legal limits for transmittances (Ministero delle Imprese e del Made in Italy, 2015) and the risk of monthly condensation in building envelope components.

7. Estimation of energy needs in the project state.

For this estimate, the same matrix tool from the TABULA project mentioned in point 5.3 (Corrado et al., 2014) was used, as the same study identifies a specific thermal consumption value for each residential building typology following standard retrofit interventions.

8. Technical feasibility assessment of new supply systems for energy self-sufficiency.

In this phase, the focus was on the energy supply of short-chain woody biomass. Some papers available in the literature were referenced for:

- 8.1. Identifying the thermal load curve (Buzzo Contin, 2013) and electrical load curve (Di Andrea & Danese, 2004) of the retrofitted settlement to size a proposal for a biomass-fueled cogeneration plant and select the appropriate technology (Comodi et al., 2010).
- 8.2. Sizing the district heating network for distributing the generated heat.
- 8.3. Verifying the amount of wood chips required, obtainable from sustainably harvested local biomass (Francescato et al., 2009).

Application of the methodology to the case study of terracino, in accumoli municipality

The following outlines the methodology and the main results applied to the case study of the village of Terracino, the highest (1165 m. above sea level) hamlet of Accumoli, which was affected by the 2016 earthquake. The settlement consists of 60 buildings, 40 of which are residential (Fig. 6) and is located in climate zone E.

1. Climatic analysis

Data analysis shows that for most of the year, temperatures are too cold and significantly deviate from the comfort range. The coldest period runs from October to April, with January being the most critical winter month (Fig. 7, Tab. 1 and Fig. 8).

The analysis of seasonal winds reveals a general prevalence of northern currents throughout the year, with some seasonal variations: in summer, the predominant winds come from the north and northeast with speeds between 10 and 20 km/h, while in autumn and winter, the spectrum expands to include eastern winds, with northerly winds often reaching speeds of around 35 km/h (Fig. 9).

2. Urban analysis

The analysis of the sun exposure of the buildings surfaces is conducted for critical days in the solar path, such as equinoxes and solstices. For a mountainous context where the main climatic issue is the winter season, the following considerations are based on the solstice, a limiting condition because the sun's path is at its lowest, resulting in minimal solar gains (Fig. 10).

3. Identification of passive strategies

The seasonal psychrometric chart analyses suggest differentiated intervention strategies on buildings to increase the comfort area passively, i.e., without the use of systems. In particular, it is primarily recommended to increase the mass exposed to solar gains combined with night ventilation for the summer season, while for the other seasons, emphasis is placed on the need for passive solar heating (Fig. 11).

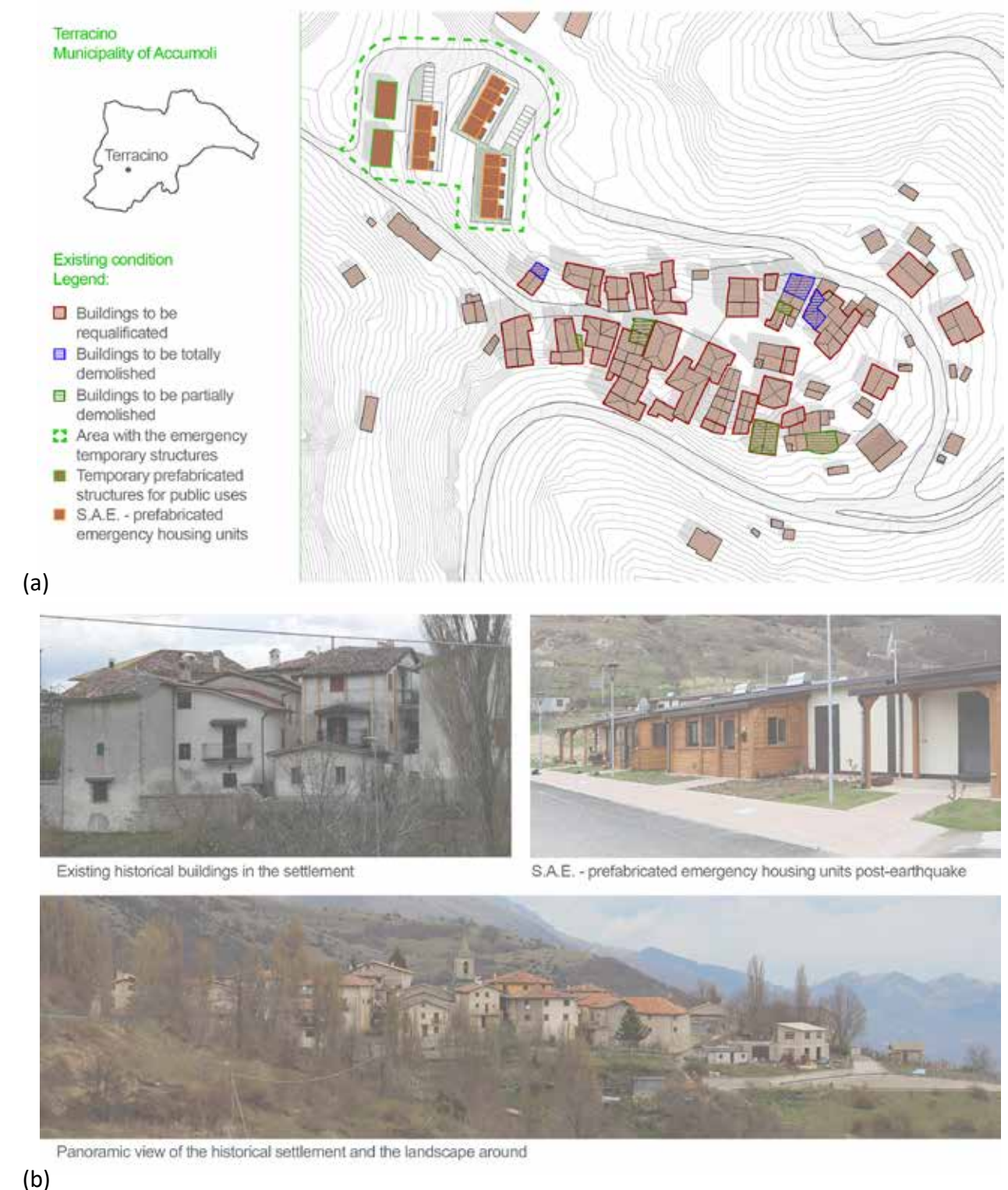


Fig. 6 a) Overview on the case study of Terracino: plan of the existing conditions of the buildings in the settlement after the earthquake. b) Photos of Terracino.

4. Analysis of local renewable energy resources.

4.1 To estimate the solar radiation available to the settlement's buildings, calculations of irradiation on vertical surfaces (Fig. 12) and roofs (Fig. 13) are provided, distinguished by azimuthal orientation. Only the surfaces which in the urban analysis showed good exposure are taken into consideration.

4.2. For the survey of sustainably harvestable biomass, the analysis of planning documents revealed an underestimation of the municipal management of forested areas compared to the forest resources present in the territory (Fig. 14).

Therefore, GIS analyses were conducted to extend the available municipal data on annual wood growth to all areas of the same forest type reported by regional cartographic documentation, accepting the inevitable underestimation of the total figure compared to the actual total extent of all local forests.

(Fig. 15). Moreover, it was shown that areas with a slope greater than 50%, which should be excluded due to difficult access, are negligible (Fig. 16).

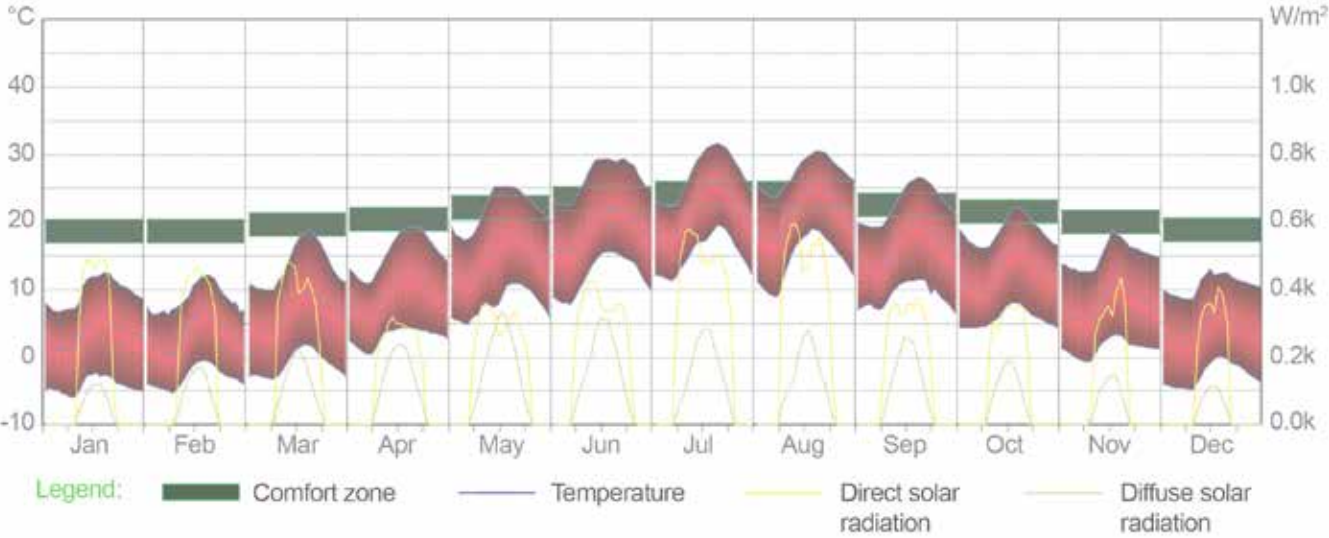


Fig. 7 - Climate data related to the daily average per month throughout the year in Terracino; elaborated with the software Meteonorm 8

Daily average	Temperature [°C]			Comfort temperature [°C]	Direct solar radiation [Wh/m²]	Diffuse solar radiation [Wh/m²]
	T _{min}	T _{avg}	T _{max}			
Winter	-4.2	3.6	10.8	17 – 20.5	3387	833
Summer	11.2	20.6	27.7	22 – 25.5	5830	2354
Spring	-1.0	10.2	21.9	19 – 22.5	3996	2016
Autumn	1.4	12.3	22.8	19.5 – 23	3290	1329
Coldest month: January	-5.4	3.1	9.5	17 – 20.5	3838	718
Hottest month: July	15.2	21.6	29.3	22.5 – 26	6724	2341
Coldest day: 22 nd January	-5.9	-4.1	-2.2	17 – 20.5	3282	1053
Hottest day: 24 th July	22.3	27.0	31.6	22.5 – 26	6666	2740

Tab 1 - : Climate data related to the daily average in Terracino with focus on the different seasons, the coldest months and days; elaborated with the software Meteonorm 8.



Fig. 8 Climate data related to the monthly heating degrees days in Terracino; elaborated by calculating the ratio between the total Heating Degree Days of Accumoli (2921 HDD) and the sum of the Heating Degree Hours recorded by the Weather Tool for the months during which heating is legally mandated.

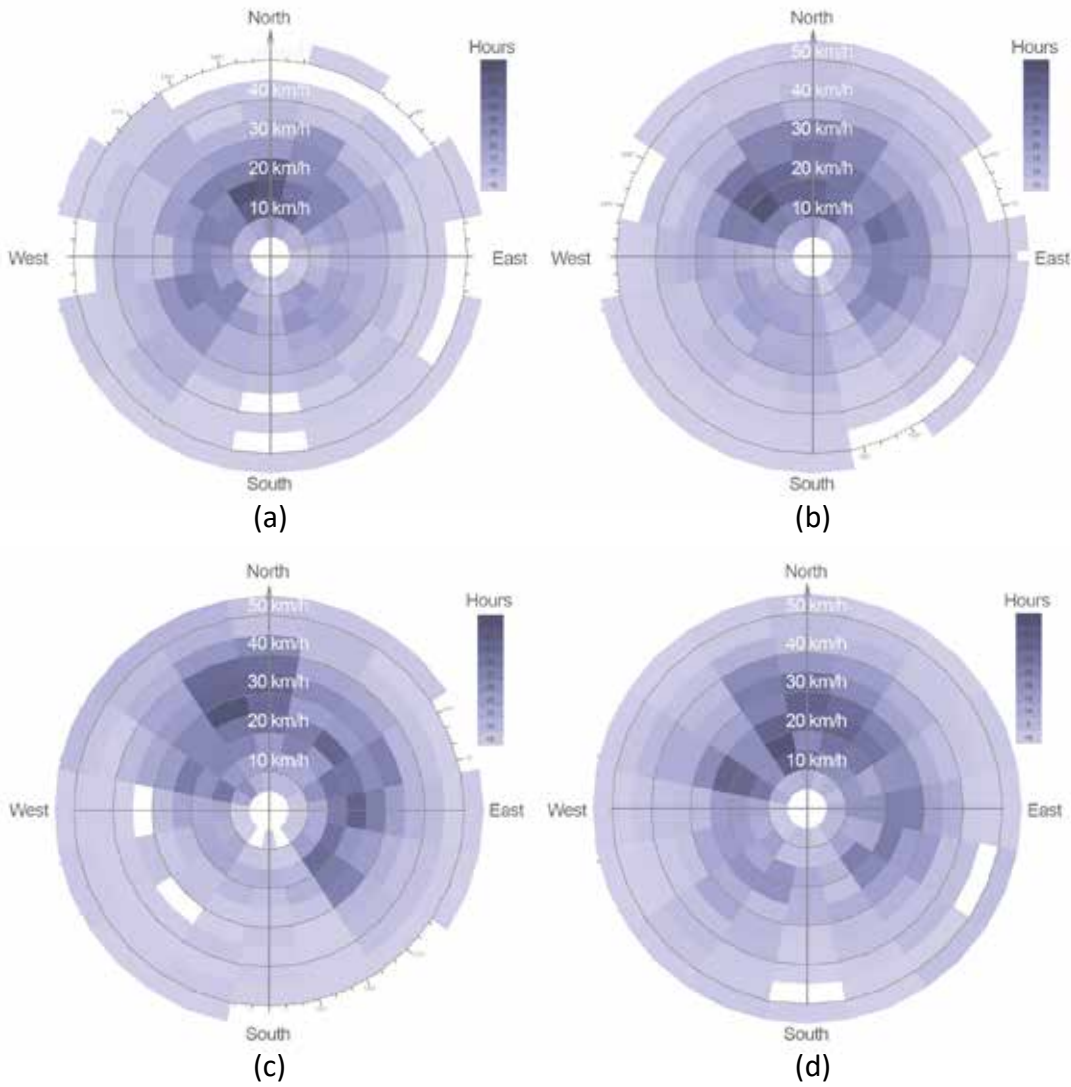
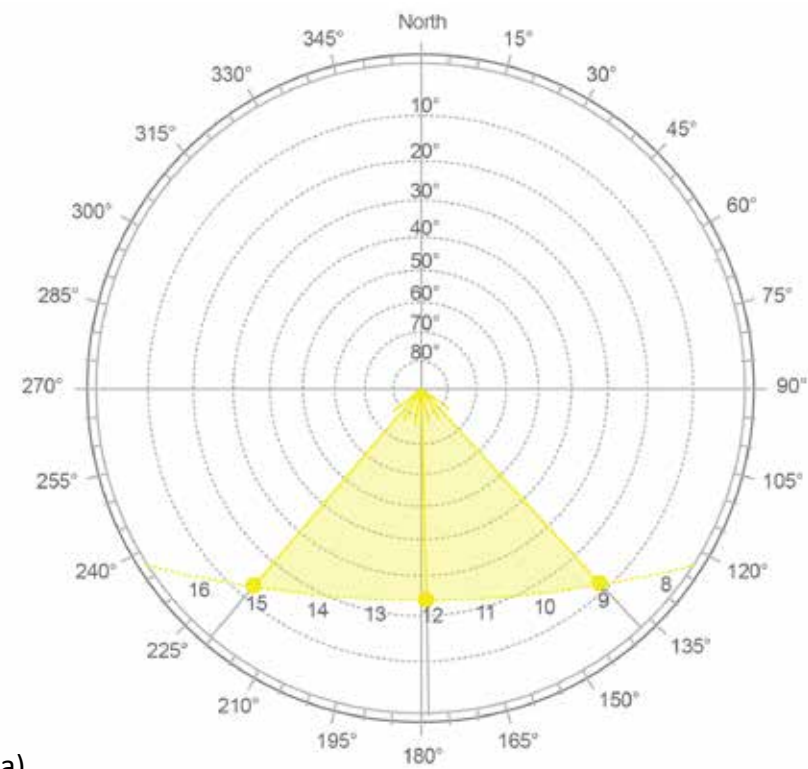


Fig. 9 Graphic of the frequency (hours), the cardinal direction and the speed of the prevailing winds during the seasons: (a) Summer season. (b) Autumn season. (c) Winter season. (d) Spring season."



(a)

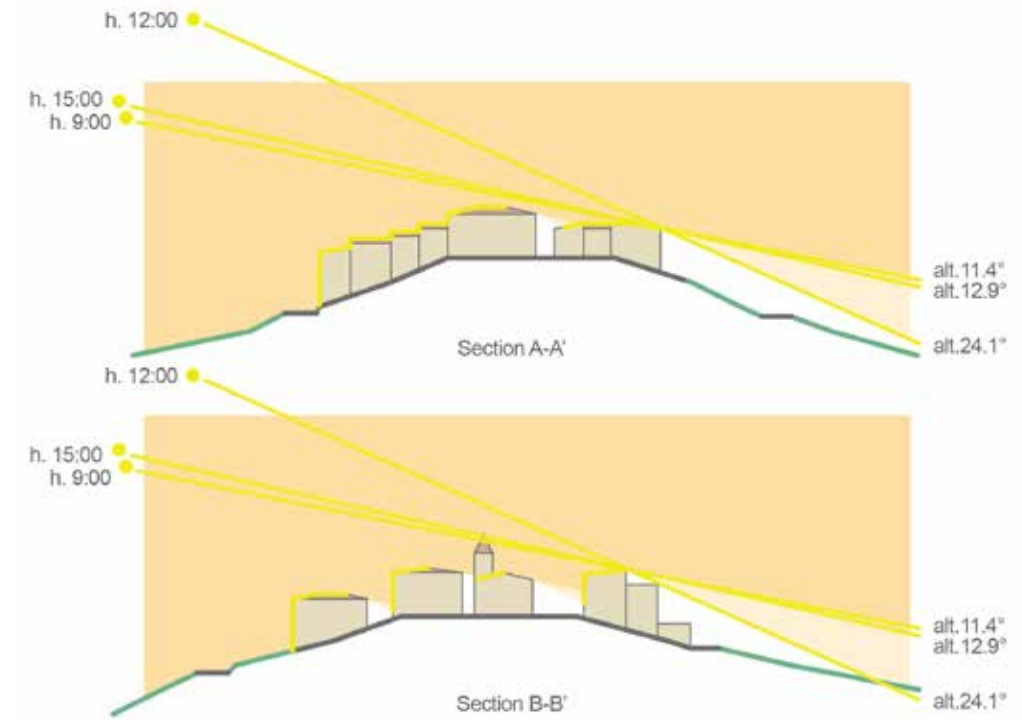


(b)



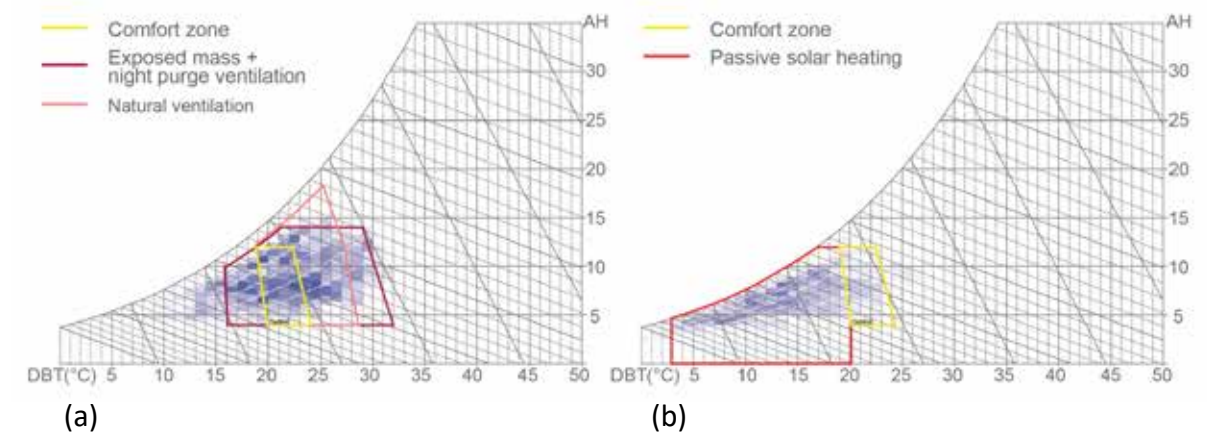
(c)

— Irradiated vertical surfaces
— Roofs with a good solar exposure



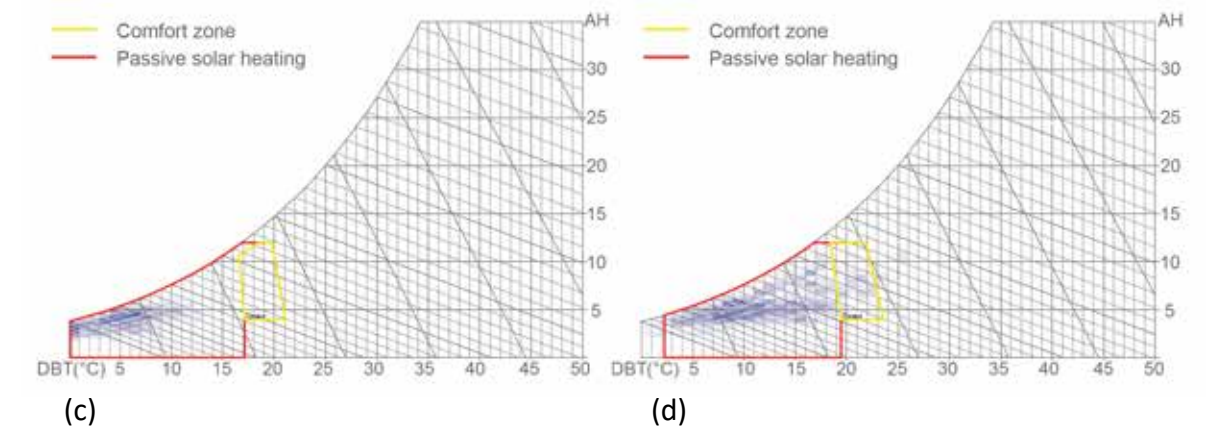
(d)

Fig.10 - Graphic analysis of the solar exposure of the settlement during the winter solstice (21st December). The settlement is mostly composed of clusters of multiple building structures, separated by very narrow alleys with limited gains in terms of solar radiation. The better exposed surfaces are the roofs and the walls of the south side of the settlement: (a) Solar path diagram. (b) 3D model with the simulation of the shadow at 9:00 a.m., 12:00 p.m and 15:00 p.m. (c) Plan of the settlement. (d) Sections of the settlement.



(a)

(b)



(c)

(d)

Fig. 11 Psychrometric diagrams highlighting in blue the temperature and humidity conditions of the outdoor air for all hours of the season, and the yellow area indicating the comfort zone. The other colored lines identify extended comfort zones achievable through the proposed interventions, even when the outdoor air temperature and humidity conditions fall outside the standard yellow area: (a) Summer season. (b) Autumn season. (c) Winter season. (d) Spring season.



(b)

Annual incident solar radiation of vertical surfaces			
Orientation of the solar exposed facades [° azimuth]	Total surfaces [m²]	Radiation per unit of surface [kWh/m²]	Total Radiation [kWh]
0°	306	Total annual: 786.75 Winter season: 153.51 Summer season: 247.44	Total annual: 240,745.5 Winter season: 46,974.06 Summer season: 75,716.64
120°	135	Total annual: 853.28 Winter season: 199.03 Summer season: 235.11	Total annual: 115,192.8 Winter season: 26,869.05 Summer season: 31,739.85
140°	634	Total annual: 931.48 Winter season: 264.76 Summer season: 204.56	Total annual: 590,558.32 Winter season: 167,857.84 Summer season: 129,691.04
160°	513	Total annual: 956.78 Winter season: 259.99 Summer season: 227.02	Total annual: 490,828.14 Winter season: 133,374.87 Summer season: 116,461.26
180°	196	Total annual: 946.59 Winter season: 207.24 Summer season: 284.54	Total annual: 185,531.64 Winter season: 40,619.04 Summer season: 55,769.84
200°			
230°			

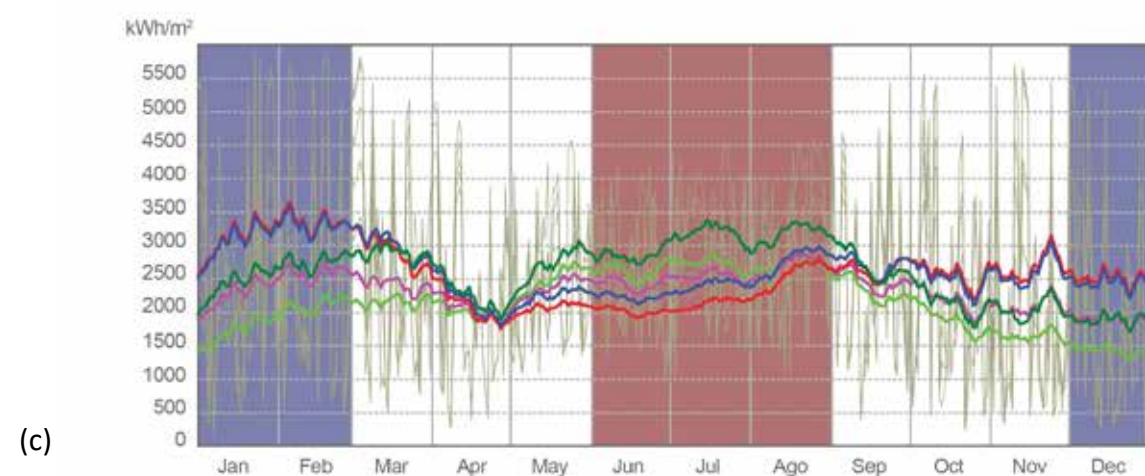
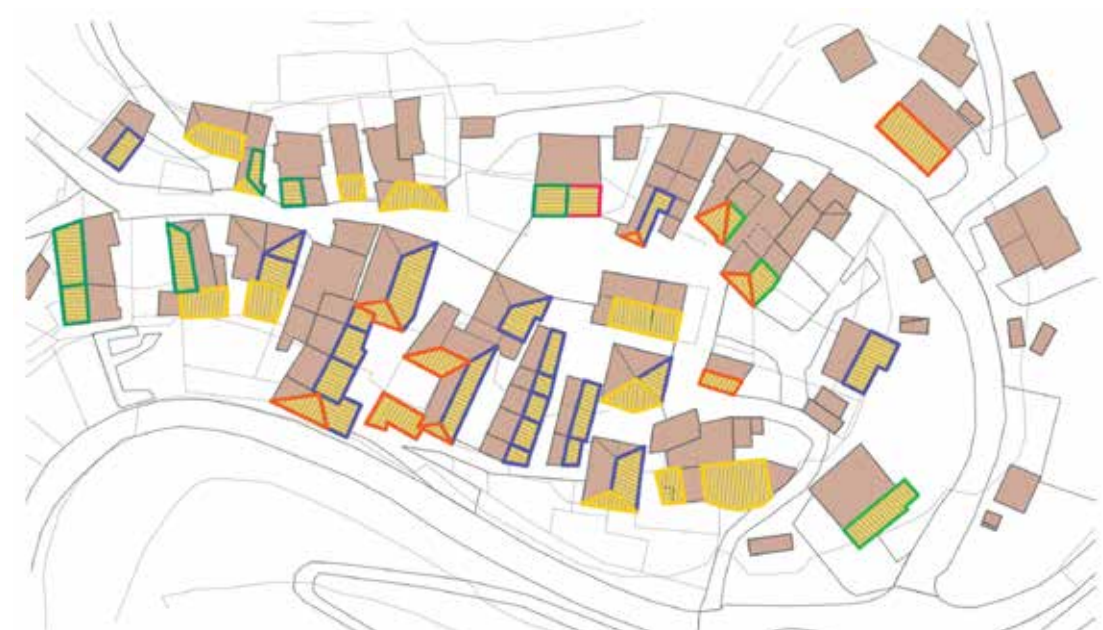


Fig. 12 (a) Plan of the analysis of the azimuthal orientation of the exposed facades in the building stock. (b) Calculation of the available irradiated vertical surfaces and the incident solar radiation during the winter season, the summer season and the annual total values, according to the different azimuthal orientation. (c) Graphic overview of the annual incident direct and diffused solar radiation for the different azimuthal oriented facades.



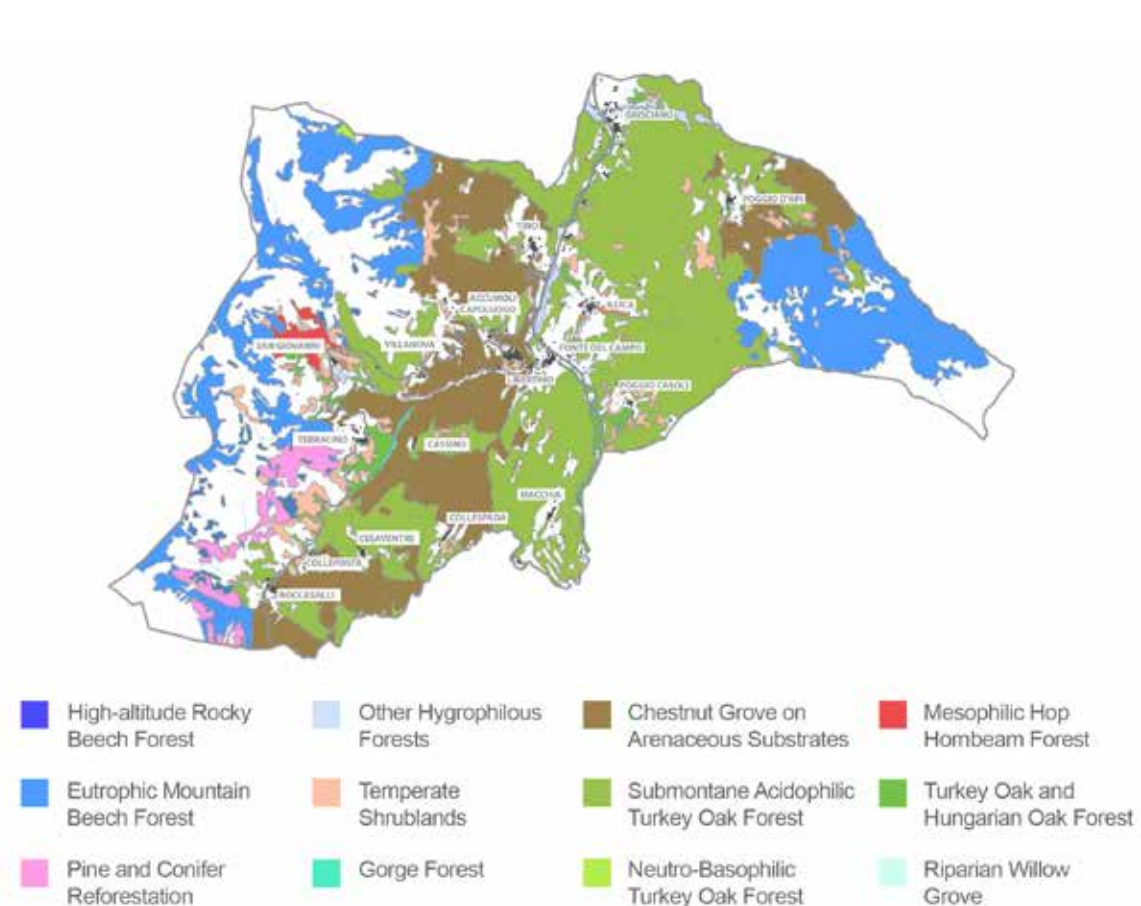
(b)

Annual incident solar radiation on roofs			
Orientation of the solar exposed facades [° azimuth]	Total surfaces [m²]	Radiation per unit of surface [kWh/m²]	Total Radiation [kWh]
0°	75	Total annual: 1,332.23 Winter season: 180.01 Summer season: 532.97	Total annual: 99,917.32 Winter season: 13,500.82 Summer season: 39,972.67
90°	790	Total annual: 1,420.05 Winter season: 215.99 Summer season: 543.68	Total annual: 1,121,836.34 Winter season: 170,632.89 Summer season: 429,505.62
110°	125	Total annual: 1,503.07 Winter season: 254.16 Summer season: 545.94	Total annual: 187,883.25 Winter season: 31,769.87 Summer season: 68,242.75
135°	512	Total annual: 1,530.31 Winter season: 278.33 Summer season: 530.41	Total annual: 783,517.18 Winter season: 142,504.45 Summer season: 271,569.41
180°	335	Total annual: 1,468.98 Winter season: 255.56 Summer season: 520.45	Total annual: 492,108.63 Winter season: 85,613.60 Summer season: 174,350.08
210°			
270°	239	Total annual: 1,227.50 Winter season: 163.35 Summer season: 485.00	Total annual: 293,372.26 Winter season: 39,041.61 Summer season: 115,915.24



Fig. 13 (a) Plan of the analysis of the azimuthal orientation of the exposed roofs in the building stock. (b) Calculation of the available irradiated roof portions and the incident solar radiation during the winter season, the summer season and the annual total values, according to the different azimuthal orientation. (c) Graphic overview of the annual incident direct and diffused solar radiation for the different azimuthal oriented roof portions.

(a)



(b)

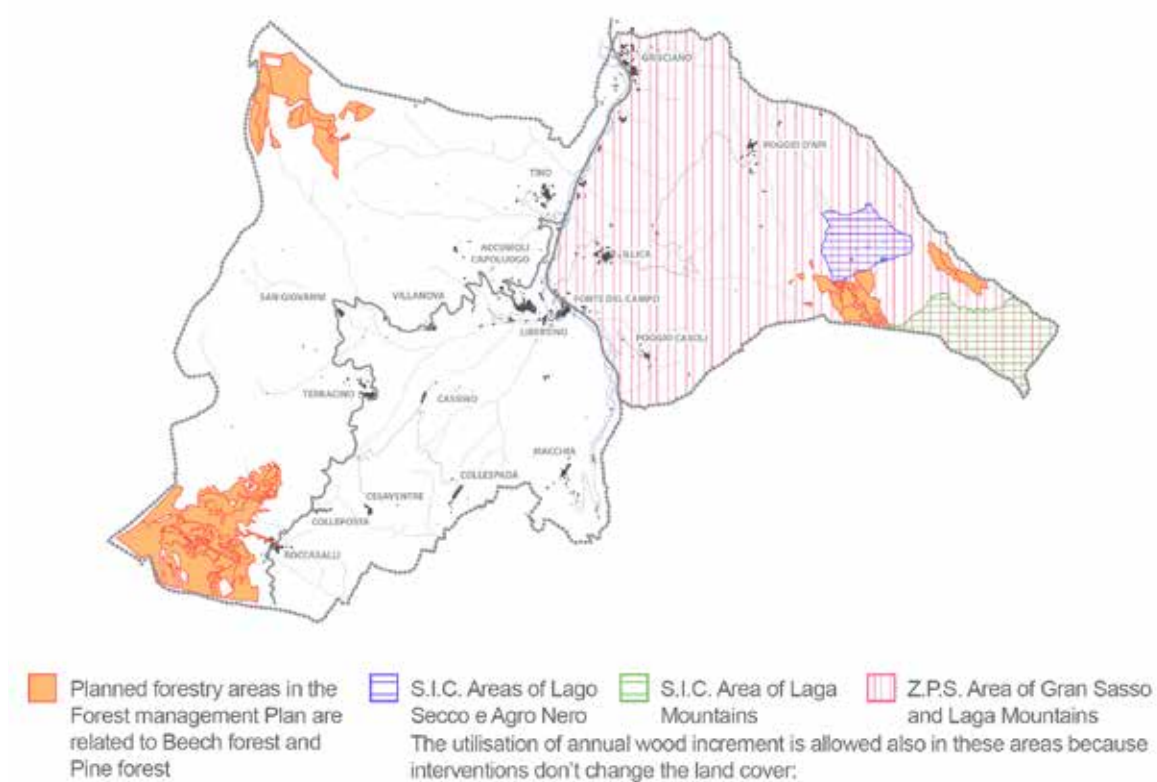


Fig. 14 (a) GIS Analyses of the of the different vegetable varieties of the forestry surfaces (Regione Lazio, 2021). (b) GIS Analysis of the planned forestry areas of Municipality of Accumoli (Ufficio Tecnico del Comune di Accumoli, 2014).

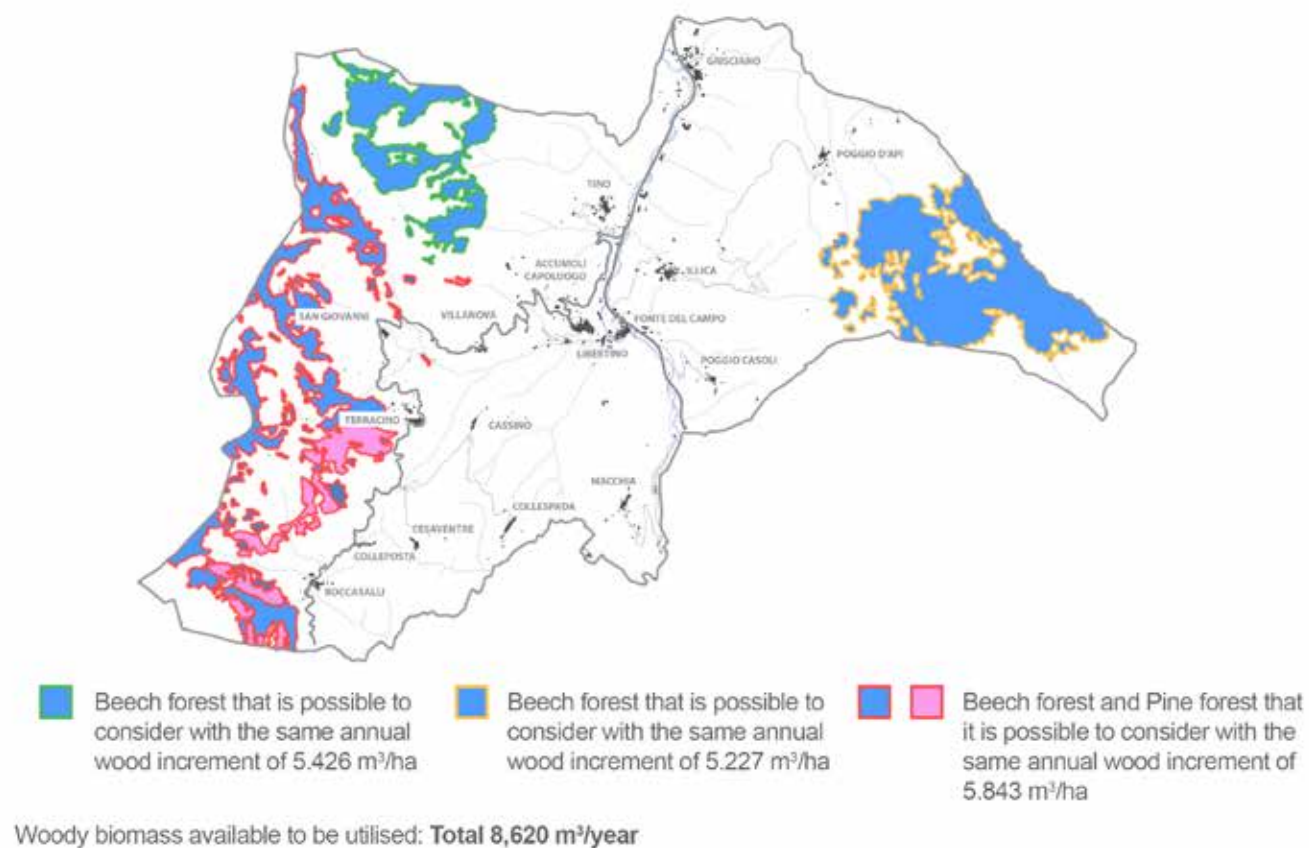


Fig. 15 - GIS Analysis of the total forestry areas considered available for the sustainable supply of the woody biomass.

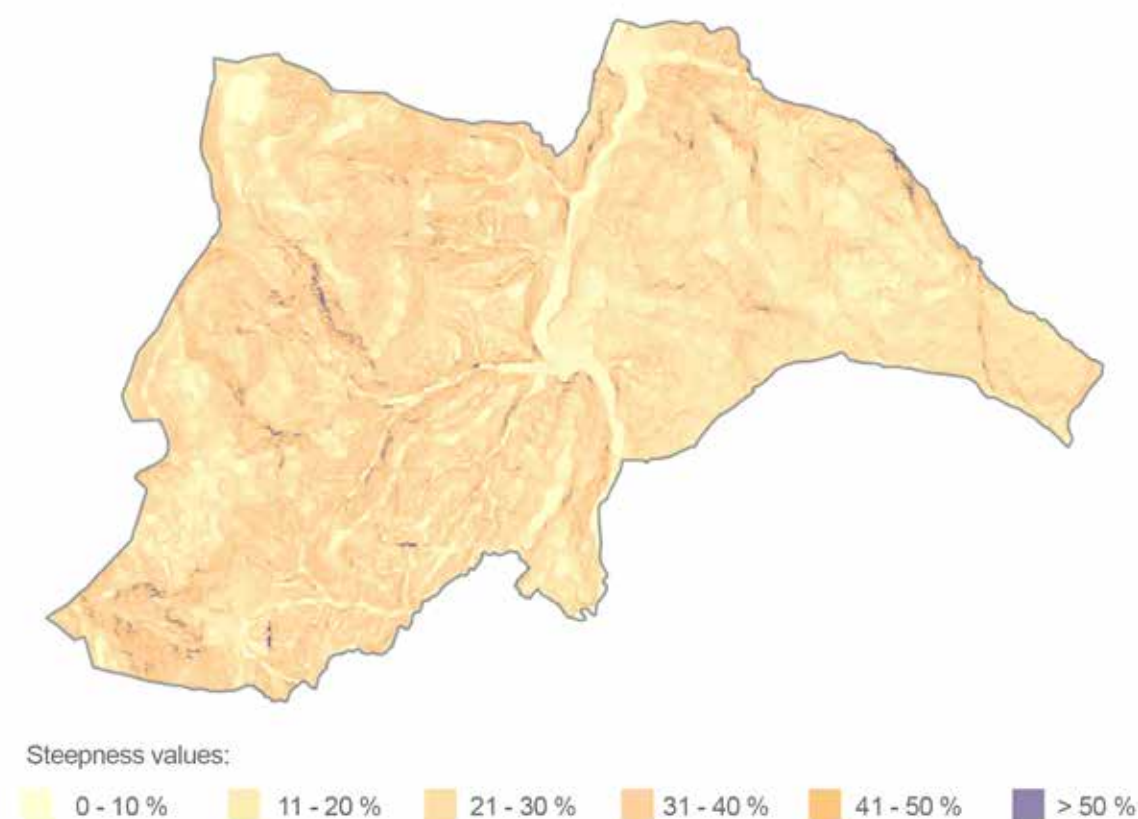


Fig. 16 - GIS Analysis of the steepness of the territory for excluding the areas with slopes more than 50% (Dipartimento per gli Affari Regionali e le Autonomie, 2015).

5. Analysis of the building stock and energy needs in the current state.

- 5.1. Some examples of thermographic results on the facades of historic buildings are reported (Fig. 17)
- 5.2. A sample of one of the datasheets created for each residential building is provided, containing cadastral data on habitable surfaces, building type, and construction period (Tab. 2) derived from on-site visual analysis (Fig. 18). By comparing them with model buildings from the TABULA matrix (Fig. 19) the entire residential building stock was estimated (Tab. 3).

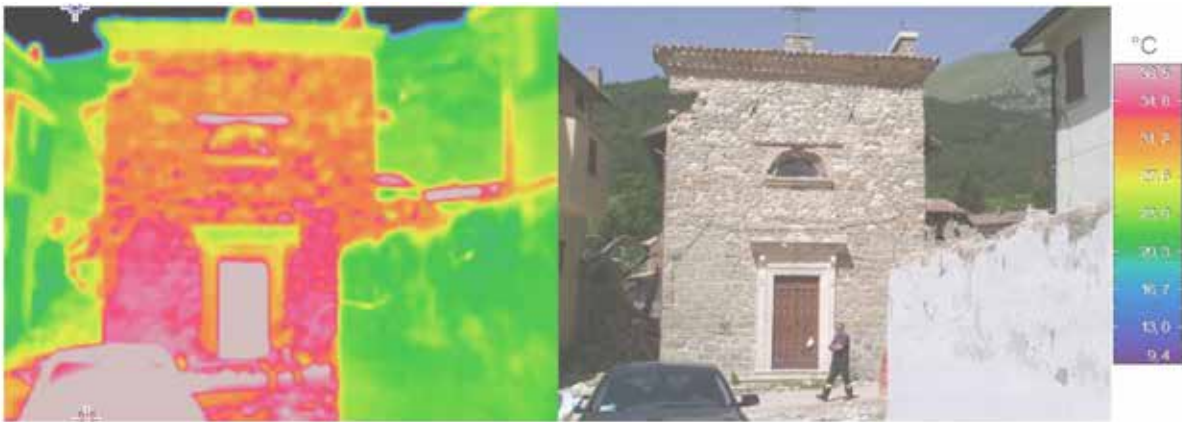


Fig. 17 Analysis of material discontinuities in construction systems using thermography. In this example, the upper part shows heterogeneous masonry with grafts of river pebbles and other irregular stones, and the lower part: shows regular masonry with homogeneous elements (Scuola di Architettura e Design dell’Università degli Studi di Camerino, 2020).

Typology of residencial building:		Multi-family building	
Cadastral Data			
Cadastral Map Sheet:		55	
Cadastral Parcel:		184	
Cadastral Typology:		A4 Cheap dwelling-house	
Cadastral Sub-Parcel:		number:	surface (m²):
		3	159.53
		5	51
		6	68
Cadastral Total Surface (m²):		278.53	
Building Volume (m³):		835.59	
Total Building Levels:		3	
Construction Data			
Period of Construction:		Before 1900	
Type of Masonry:		Irregular masonry texture	
Type of Slab:		Timber	

Tab. 2 Example of the assessment schedule for an historical residential building.

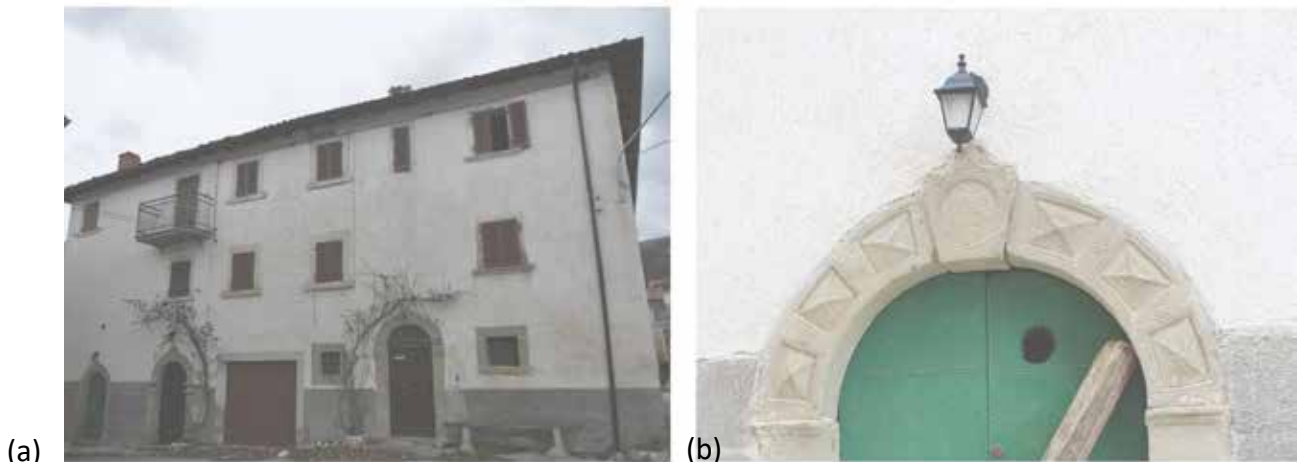


Fig.18 Photos for the visual analysis of the building referred to the Table 2: (a) Photo of the whole building. (b) Focus on the inscription visible on the stone portal, that indicates the year 1827.

	Single-family house	Row houses	Multi-family buildings	Flat blocks
Before 1900				
1901-1920				
1921-1945 post-World War I				
1946 - 1960 post W-W II and Reconstruction				
1961 - 1975 oil crisis				
1976 - 1990 early energy regulations				
1991 - 2005 new regulations				
After 2005 increased restriction				

Fig.19 Categorisation of Building models in TABULA matrix for Italian residential stock in Climate Zone E (Corrado et al., 2014).

Period of Construction	Single-family houses [m²]	Row houses [m²]	Multi-family buildings [m²]
Before 1900	2,534.08	599.86	3,189.26
1901 – 1920	506.32	-	-
1921 – 1945	68.37	-	-
1946 – 1960	886.00	-	-
1961 – 1975	-	-	-
1976 – 1990	-	-	-
1991 – 2005	163.00	-	-
After 2005	-	-	-

Tab. 3 Assessment of the residential building stock of the Terracino settlement.

- 5.3. The estimated net thermal energy needs of the historic buildings in their current state, based on the previously derived building stock, are presented, obtained by comparing them with the specific needs of model buildings from the TABULA matrix (Fig. 20 and Tab. 4).

Typology of residencial building: Single-family house				
Net floor area of the dwelling: 139 m² Numero of residencial unit: 1 Number of heated floors: 2				
Building envelope construction type				
 Pitched roof with wooden structure and decking	 Striped stone masonry with bricks (40 cm)	 Concrete slab on the ground	 Single glazing and metal frame without thermal	
Roof	Wall	Ground floor slab	Windows	
U [W/m²K]	U [W/m²K]	U [W/m²K]	U [W/m²K]	g _{g,n} [-]
1,80	1,61	2,00	5,70	0,85
Energy performance				
Net heating demand Q _{h,nd} = 335 kWh/m²			Net heating demand for domestic hot water Q _{wh,nd} = 15 kWh/m²	

Fig. 20 Example of the energy performance assessment schedule for an historical residential building model in TABULA (Corrado et al., 2014).

Period of Construction	Heating demand for Single-family houses [kWh/year]	Heating demand for Row houses [kWh/year]	Heating demand for Multi-family buildings [kWh/year]
Before 1900	886,928.00	127,402.83	848,662.09
1901 – 1920	188,705.46	-	-
1921 – 1945	23,970.52	-	-
1946 – 1960	256,408.40	-	-
1961 – 1975	-	-	-
1976 – 1990	-	-	-
1991 – 2005	17,359.50	-	-
After 2005	-	-	-
Total net heating demand:	2,349,436.80 kWh/year		

Tab. 4 Assessment of the total net heating demand for the residential building stock in Terracino settlement. The heating demand includes the ambient heating demand and the domestic hot water demand.

5.4. The estimated electrical energy needs of the buildings in their current state, obtained by comparing them with data from the MICENE study, are shown (Fig. 21).

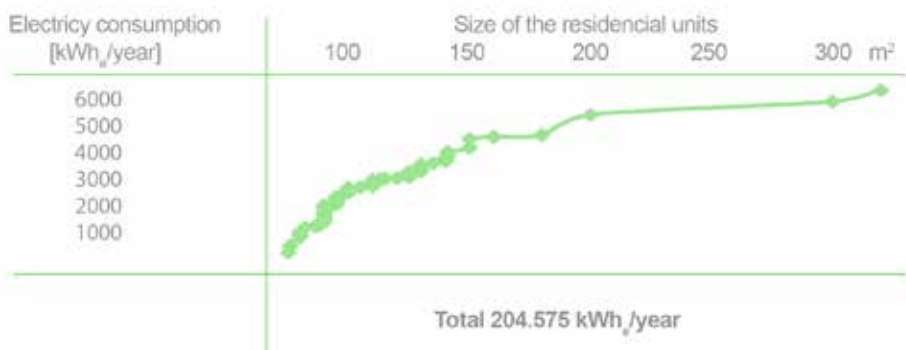


Fig.21 Assessment of the total electrical demand for the residential building stock in Terracino settlement.

6. Identification of intervention strategies and technical-design solutions at the building scale. The suggested energy retrofit strategies for the building envelope (Fig. 22) mostly sought to consider natural materials with breathable characteristics compatible with historic stone buildings, favoring wood-based products that could be part of a local supply chain.

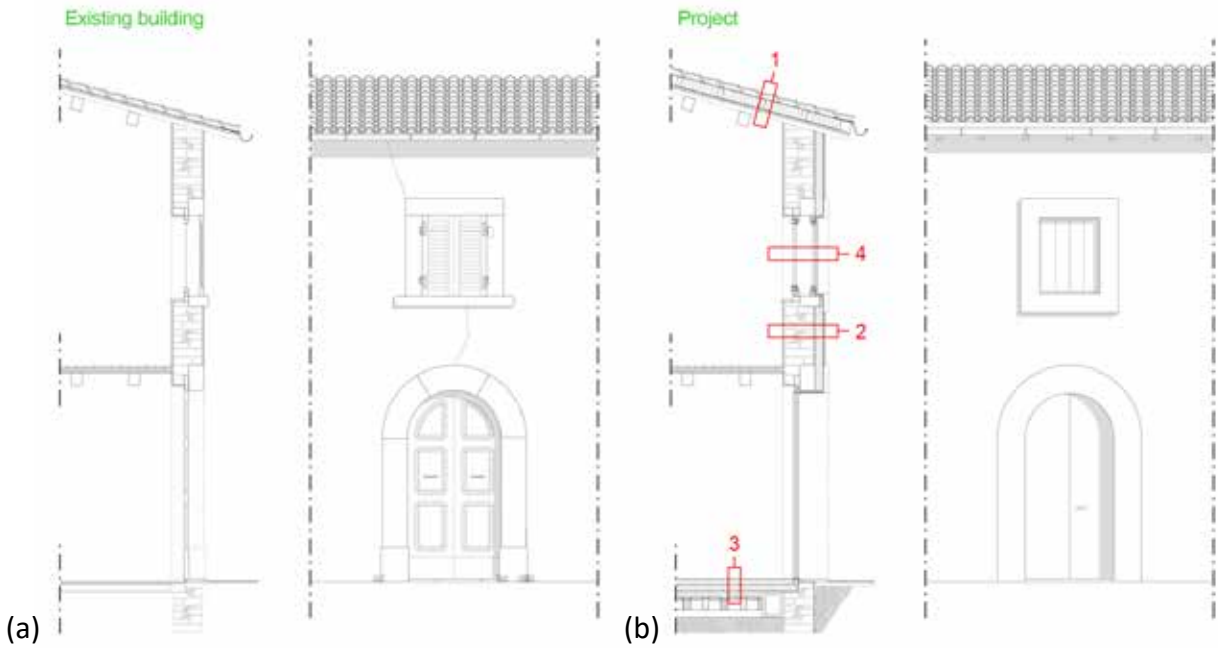


Fig.22 - Example of the intervention on an historical residential building in Terracino: (a) Existing condition. (b) Renovated condition: 1 – Intervention on the roof; 2 – intervention on the opaque vertical partitions of the building envelope; 3 – Intervention on the ground floor slab; 4 – Intervention on the windows.

6.1 Intervention on roofs. For roofs, made of wooden boards and tiles, an insulating cladding was proposed on the outer side of the structure, with wood fiber panels placed between the wooden sheathing and the tile covering (Fig. 23).

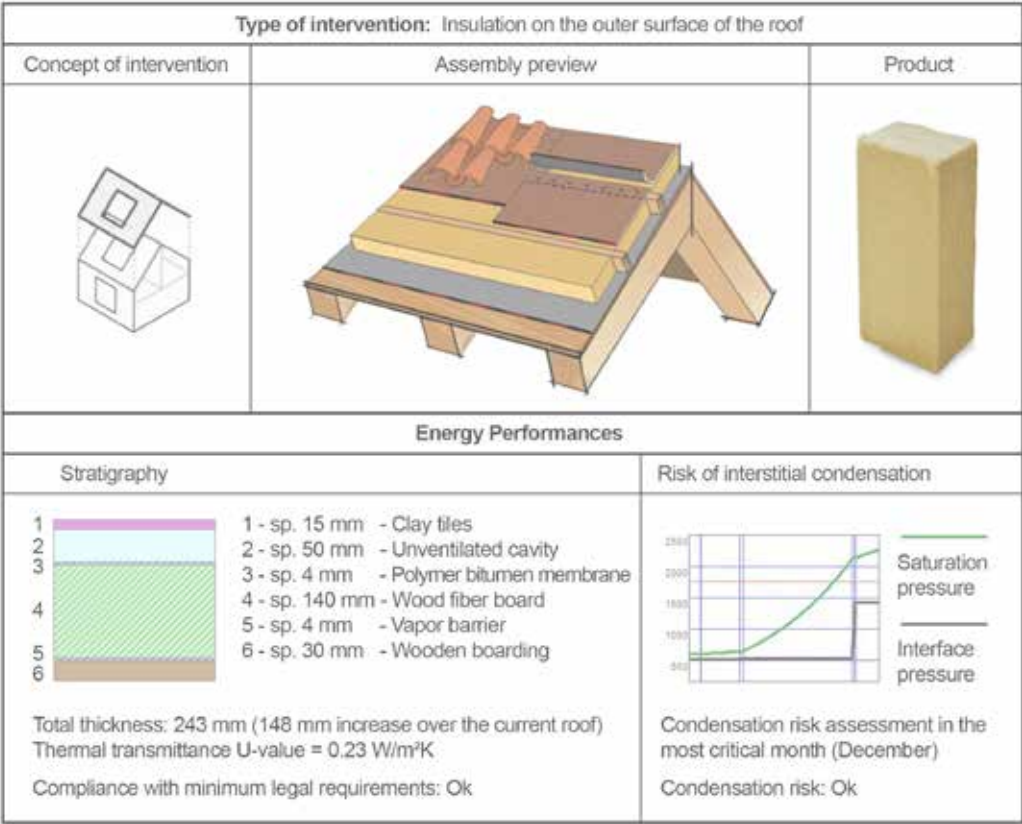
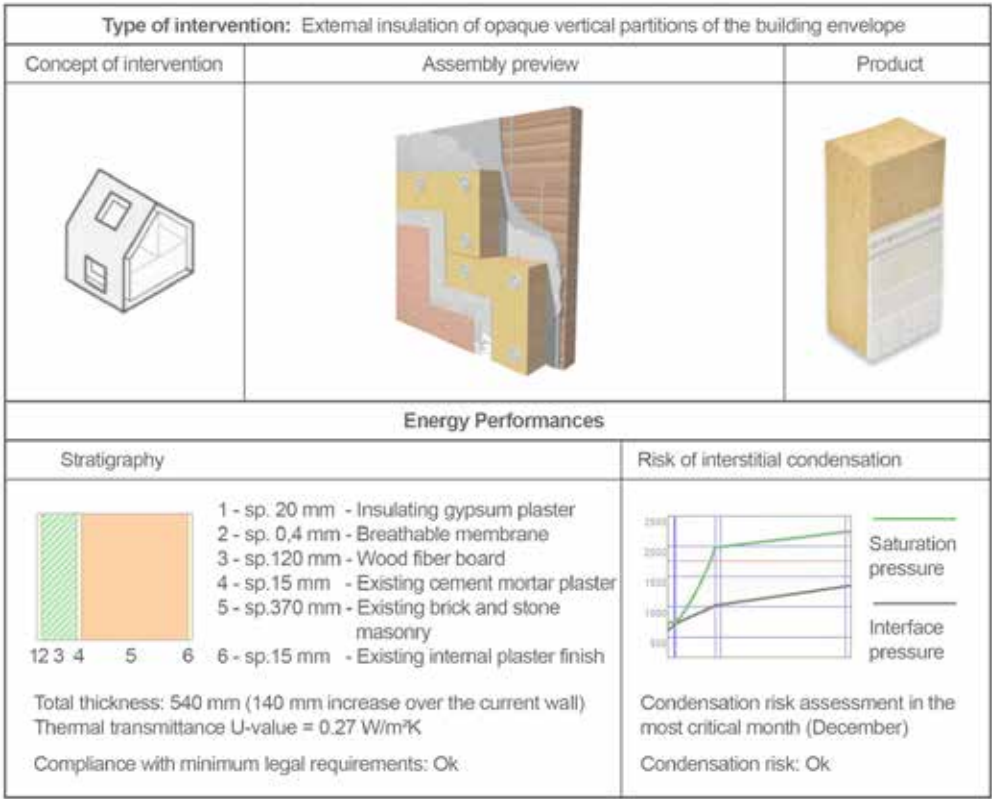


Fig.23 - Schedule of the intervention of energy efficiency of the roof.

6.2 Interventions on vertical opaque structures.

For the external wall, made of load-bearing stone masonry, sometimes exposed, sometimes plastered, a double hypothesis was proposed: external insulation with wood fiber panels and internal lining with reflective thermal insulation (Fig. 24);

(a)



(b)

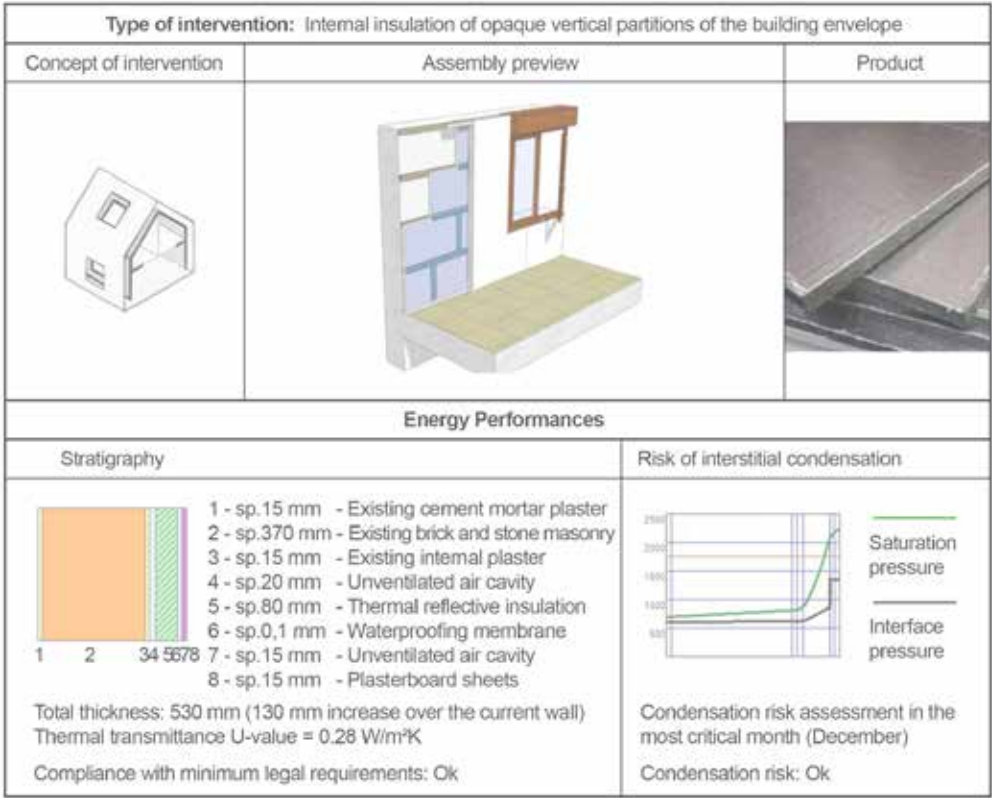
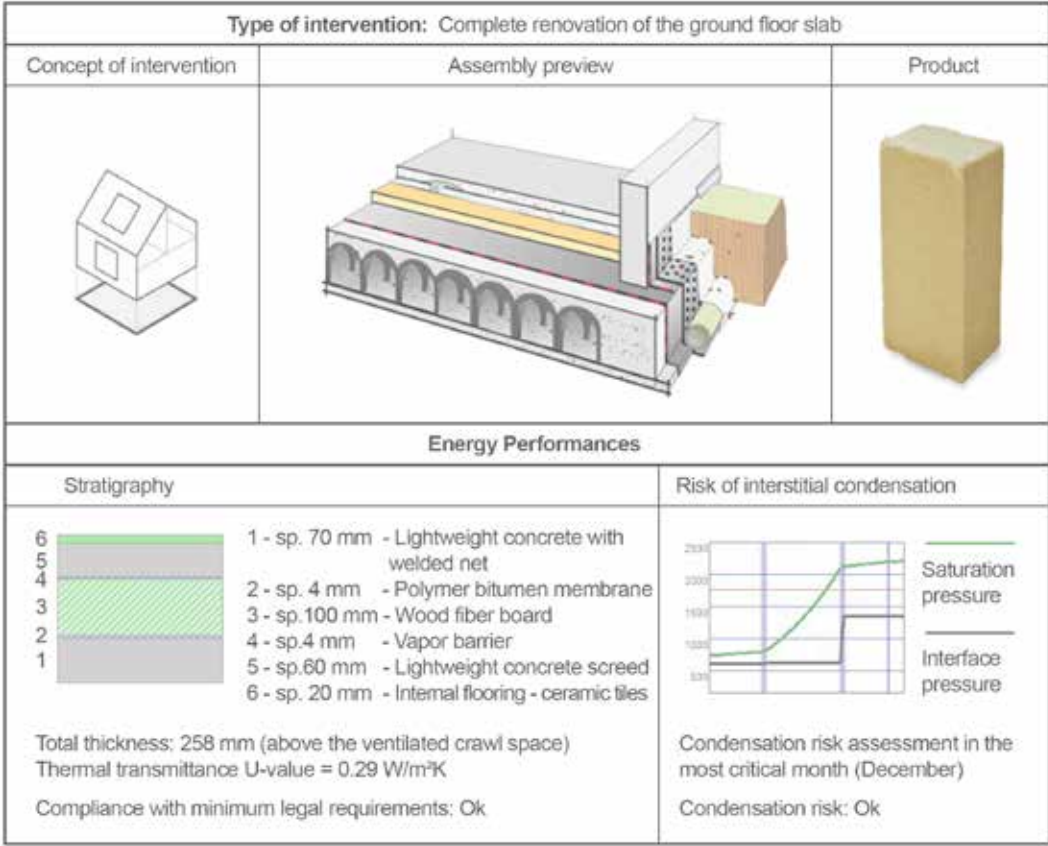


Fig.24 - Schedule of the intervention of energy efficiency of the vertical partitions of the building envelope: (a) Intervention of external insulation. (b) Intervention of internal insulation.

6.3. Intervention on slabs in contact with the ground.

For slabs in contact with the ground, consisting of a simple concrete base on the ground, complete replacement was suggested in conjunction with seismic reinforcement of the foundations, and a new floor on a ventilated crawl space with wood fiber insulation was considered (Fig. 25);

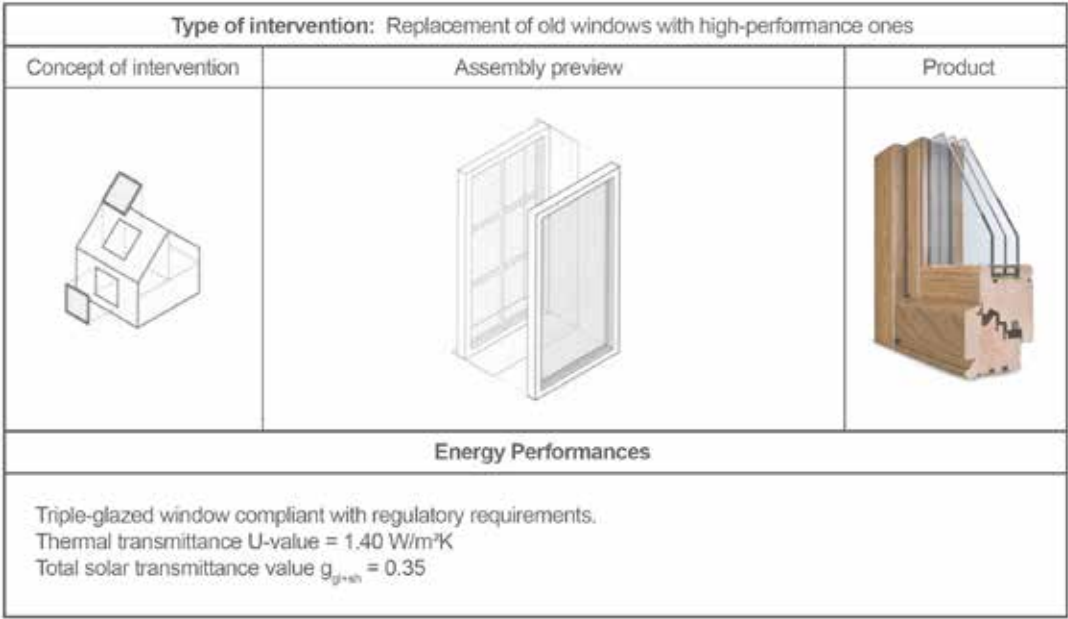
Fig.25 Schedule of the intervention of energy efficiency of the ground floor slab.



6.4. Windows.

It was suggested to replace the current windows, which have single glazing and frames without thermal breaks, with new ones that comply with legal standards (Fig. 26).;

Fig.26 Schedule of the intervention of energy efficiency of the windows.



7. Estimation of energy needs in the project state..

The estimated net thermal energy needs of the retrofitted historic buildings, as determined by comparison with model buildings from the TABULA matrix (Corrado et al., 2014) are presented (Tab. 5). The electrical needs are considered unchanged.;

Period of Construction	Heating demand for Single-family houses [kWh/year]	Heating demand for Row houses [kWh/year]	Heating demand for Multi-family buildings [kWh/year]
Before 1900	211,088.86	34,729.87	255,778.66
1901 – 1920	44,606.79	-	-
1921 – 1945	6,009.72	-	-
1946 – 1960	69,285.20	-	-
1961 – 1975	-	-	-
1976 – 1990	-	-	-
1991 – 2005	10,432.00	-	-
After 2005	-	-	-
Total net heating demand:	631,931.10 kWh/year		

Tab.5 Assessment of the total net heating demand for the residential building stock in Terracino settlement after the energy renovation. The heating demand includes the ambient heating demand and the domestic hot water demand.

8. Technical feasibility assessment of new supply systems for energy self-sufficiency.

Results from studies of a cogeneration plant designed to meet the entire energy needs of residential buildings, distribute thermal energy through a district heating network, and feed electricity into the grid are reported.

8.1. Graphs of daily thermal and electrical load needs and cogenerator production are reported (Fig. 27), as well as the chosen system layout (Fig. 28 and Tab. 6).

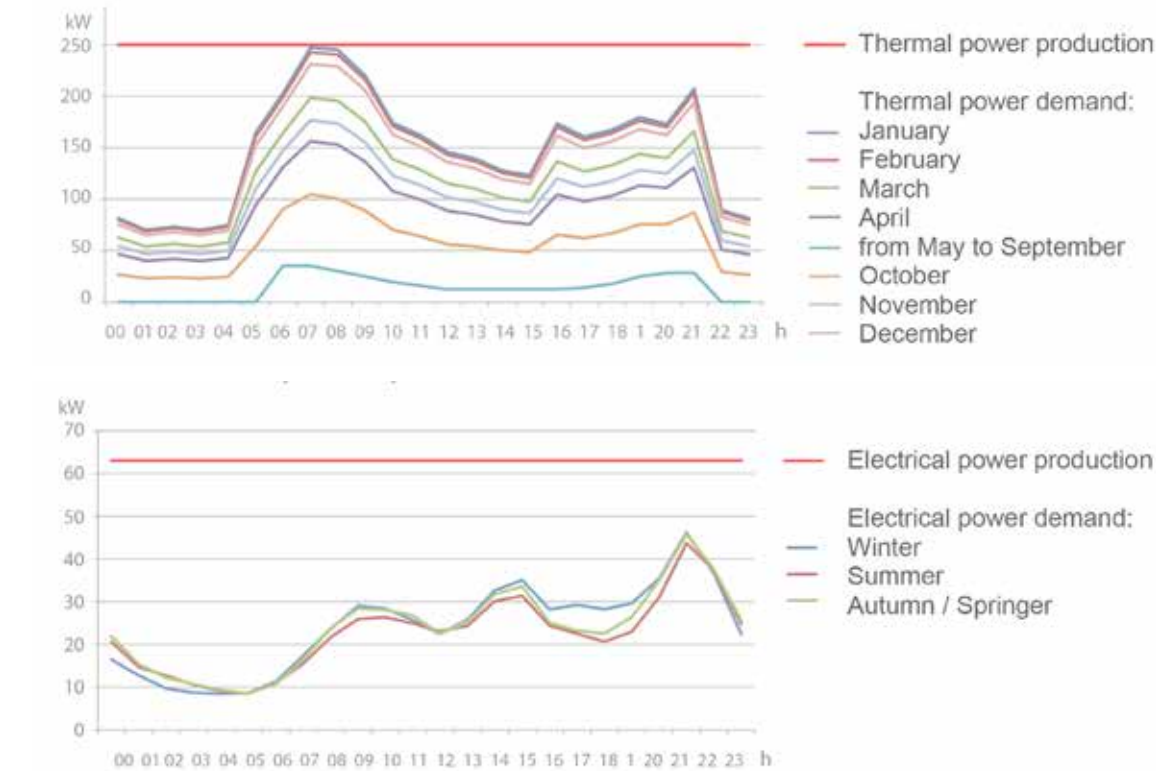


Fig. 27 (a) Daily loads of thermal energy demand from the renovated residential building stock settlement and thermal energy produced by the cogeneration plant. (b) Daily loads of electric energy demand from the renovated residential building stock settlement and thermal energy produced by the cogeneration plant.

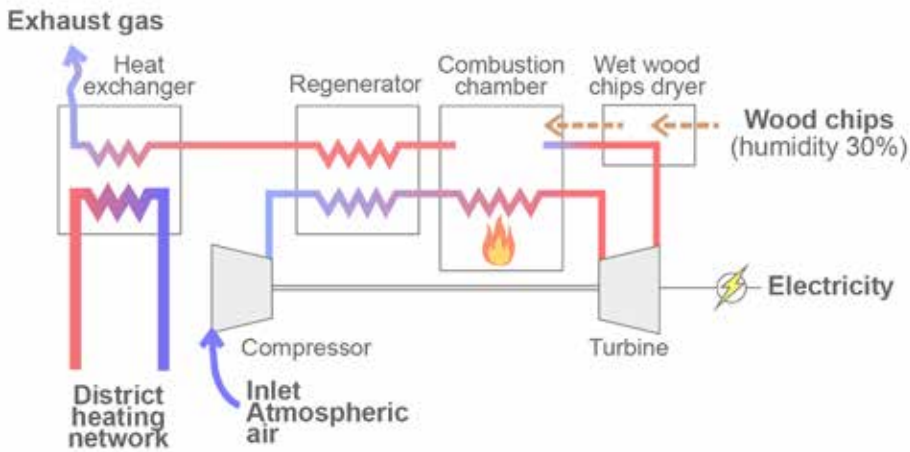


Fig. 28 Plant scheme.

Externally Fired Micro Gas Turbine performance parameters	
Electrical Power:	75 kW _e
Thermal power:	300 kW _t
Electrical Efficiency:	η_e 17%
Thermal efficiency:	η_t 66%
Combined heat and power Efficiency:	η 83%

Tab.6 Parameter of Energy Performance of the Cogeneration Plant.

8.2 The layout of the district heating network, pipe sizing, and pumping power are shown (Fig. 29 and Tab. 7).

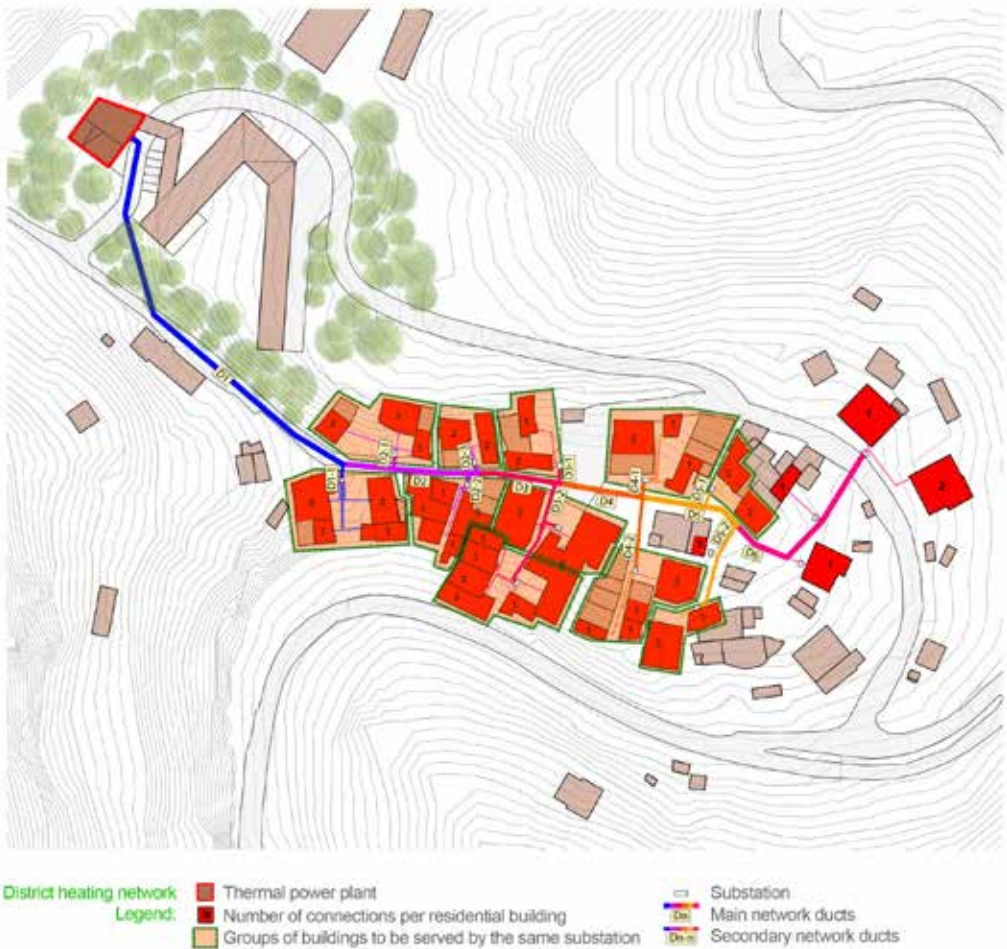


Fig. 29 Masterplan of the District heating network project for Terracino.

	Ducts	Nominal Diameter [mm]	Supply Temp. (winter) [°C]	Return Temp. (winter) [°C]	Hourly Supply Losses [kWh/h]	Hourly Return Losses [kWh/h]	Thermal Power Produced [kW]	Thermal Losses (winter) [%]	Pumping Power [kW]
Main network ducts	D1	125	92	60	6.25	3.87	1,675	2%	2,2
	D2	100	92	60	1.71	1.06			
	D3	100	92	60	1.00	0.62			
	D4	65	92	60	1.19	0.74			
	D5	50	92	60	0.99	0.61			
	D6	32	92	60	1.45	0.90			
Secondary network ducts	D1-1	40	92	60	0.18	0.11			
	D2-1	32	92	60	0.26	0.16			
	D2-2	32	92	60	0.13	0.08			
	D2-3	32	92	60	0.32	0.20			
	D3-1	25	92	60	0.28	0.17			
	D3-2	65	92	60	1.23	0.76			
	D4-1	25	92	60	0.18	0.11			
	D4-2	32	92	60	0.66	0.41			
	D5-1	25	92	60	0.13	0.08			
	D5-2	50	92	60	0.89	0.55			
Total					16.84	10.42			

Tab. 7 Sizing of the pipes of the district heating network, and calculation of heat losses along the ducts and the pumping power required for distributing hot water to the users..

8.3 Finally, a table for verifying the amount of wood chips required and comparing it with the sustainably harvestable biomass available locally is provided (Tab. 8).

Annual Energy Production	
Total heat and electrical energy production:	2,737,500 kWh/year
Combined heat and power Efficiency of the plant:	η 83%Total
primary energy required:	3,298,193 kWh/year
Annual woody biomass required	
Beech wood chips required (30% humidity, calorific value 1,102 kWh/msr):	2,993 msr/year
Wood to be chipped:	998 m³
Annual wood increment:	8,620 m³
Rate of wood material for energy production out of the annual wood increment:	11.6 %

Tab.8 The table shows a summary of the final energy produced and the primary energy required for that generation, the verification of the corresponding amount of wood biomass needed, and the comparison with the total biomass previously quantified as available for sustainable harvesting.

Conclusions

The forced condition of post-disaster reconstruction necessitates a rethinking of the energy quality and comfort of the built environment. It is possible to respond to a highly challenging situation by transforming the crisis into an opportunity.

This methodology aims to guide designers and planners in the post-disaster reconstruction process for more effective and efficient development of strategies in harmonious alignment with the potential of the context. Suggestions are made for the renovation at the building component level, and the possibility of energy self-sufficiency based on local resources is also explored, in line with European expectations for reducing energy needs and implementing collective energy supply and exchange systems at the community level.

The results of applying the methodology to a case study demonstrate that good performance in terms of energy efficiency of buildings can be achieved through interventions that respect the historical values of the local architecture, and that energy self-sufficiency based on local renewable resources is possible. Specifically, focusing on the forestry resource of the case study, just 11.6% of the wood biomass considered for sustainable harvesting, already underestimated compared to the total forest area due to current planning limits, could

meet the energy needs of an entire village by powering a small-scale cogeneration plant, which could distribute heat through a district heating network, and feed electricity into a community-owned grid.

The wood chip requirement, covering a small percentage of the total harvestable biomass, shows that it can be considered as a secondary product of a wood production chain primarily focused on other sectors, with only a marginal portion allocated to energy purposes, in a circular business perspective and in line with European recommendations. So, the social-economic revival of the territory can converge with the goal of reduce energy costs and increase the security of energy supply to the communities.

Furthermore, the establishment of a facility for producing and storing wood chips and housing the cogeneration plant could also be a future functional conversion option for the area currently urbanized to host emergency housing accommodations, with the symbolic value of supporting and promoting a more comfortable and prosperous new life in the renewed original village (Fig. 30).

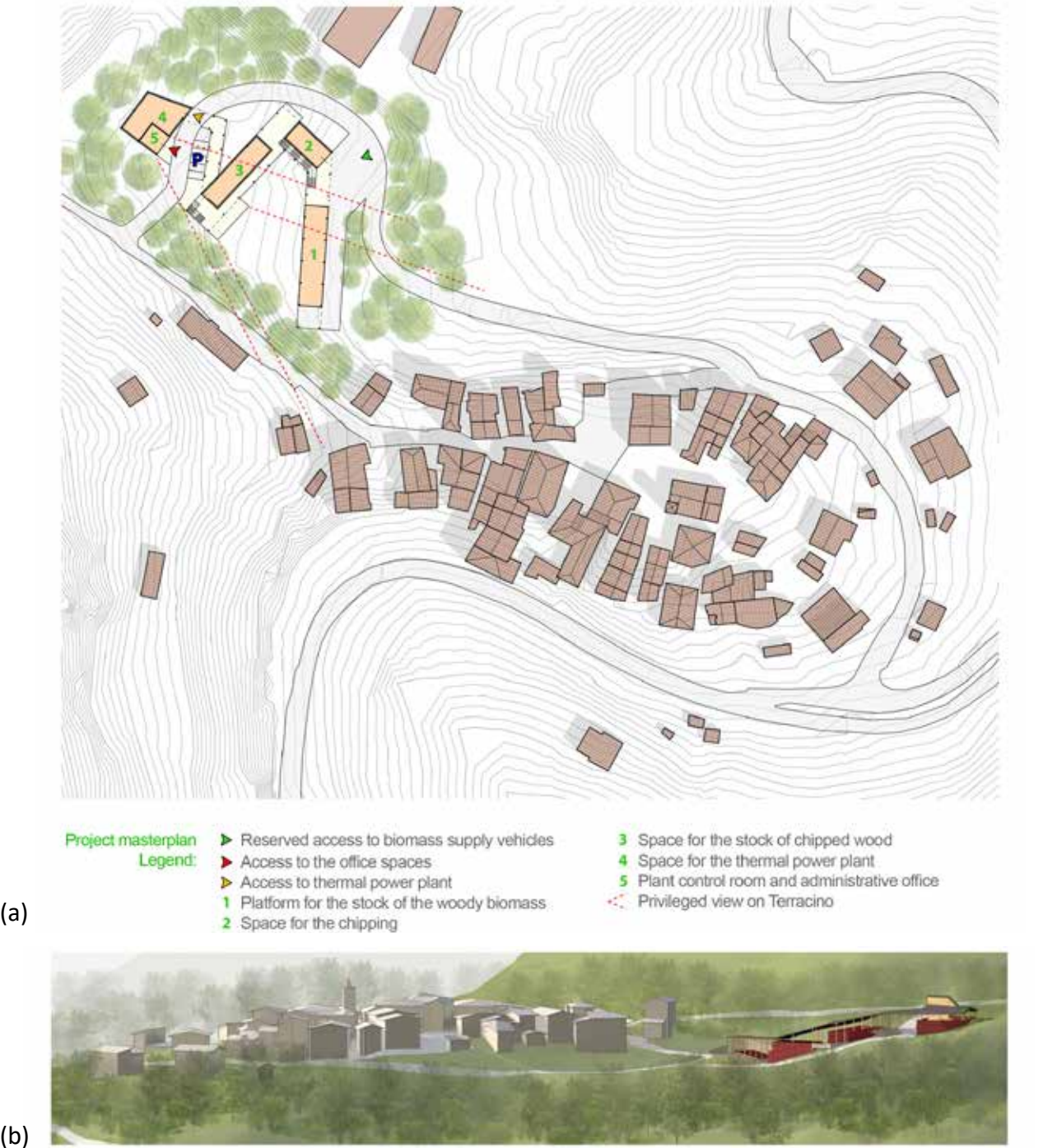


Fig. 30 - Project for the transformation of the S.A.E. area into a production plant for the transformation of woody biomass into energy to satisfy the needs of the entire existing re-qualified residential housing: (a) Masterplan. (b) View of the integration of the project in the surrounding landscape and relationship with the historical village..

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STRUCTURAL ENGINEERING AND SAFE CONSTRUCTIONS IN SEISMIC AREAS

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Abstract

Earthquakes have always been a danger that builders of all ages have had to deal with. Numerous solutions have been explored to create buildings capable of resisting earthquakes, from ancient times to modern seismic engineering which today can benefit from the systematization of scientific knowledge, technological innovations, and direct observations of the consequences of earthquakes on buildings. The current approach to seismic design commonly requires buildings to be designed to survive earthquakes, ensuring people can exit the building. It is therefore normal for buildings to be heavily damaged during earthquakes and that their recovery can be extremely expensive and often not convenient. There are alternative approaches to seismic design capable of guaranteeing negligible damage and their use must be evaluated considering the costs of construction and for repairing damage due to earthquakes, as part of a life cycle analysis of the building. Seismic action is a dynamic horizontal action that produces an oscillating motion of the building. Hence, the rules of static design for actions that always act downwards are no longer useful and the design approach must be based on the analysis and evaluation of three fundamental parameters: mass, period, and dissipation. This chapter proposes a discussion of the role of these three parameters, illustrating in a simple way methods and tools currently available to guarantee the safety of buildings in seismic areas, with specific interest for existing buildings in general and for buildings with historical and monumental value in particular.

Introduction: the state of the art in the design of buildings in seismic areas

FUNDAMENTAL CONCEPTS

Earthquakes have always been a danger that builders of all ages have had to deal with. Numerous solutions have been explored to create buildings capable of resisting earthquakes throughout human history, from antiquity to modern seismic engineering. Today the design culture in seismic areas can benefit from the systematization of scientific knowledge, technological innovations, and direct observations of the consequences of earthquakes on existing buildings. We thus know how to achieve acceptable levels of safety when we design a new construction and we know how to do it for a vast category of typologies that include reinforced concrete, steel, wooden and masonry structures (Bozorgnia and Bertero 2004).

It should be borne in mind that in the usual approach to seismic design, buildings are designed to survive earthquakes, meaning they must be able to ensure people are able to stay alive and exit the building. It is therefore normal for buildings to be heavily damaged during earthquakes and that their recovery can be extremely expensive and often not convenient. There are alternative approaches to seismic design capable of guaranteeing negligible damage and their use must be evaluated in terms of cost-benefit ratio, because conscious seismic design should always consider not only the immediate costs of construction but also the costs expected in the life cycle for the repair of damage due to earthquakes.

Unlike gravitational actions, directed vertically and due to its own weight and overloads, seismic action is a dynamic horizontal action that produces an oscillating motion of the building (Chopra 2001). The rules and parameters that control traditional design, mainly oriented towards satisfying the requests for actions that act statically and always downwards, are no longer useful in the field of dynamics and the design approach must be based on alternative parameters, identify, and satisfy different performance requirements, generating new systems and structural forms.

While the approach to structural design, of a static nature, sought solutions starting from two fundamental characteristics of the structure, stiffness and resistance, a dynamic design is developed based on three fundamental parameters: mass, period, and dissipation.

MASS

The role played by the overall mass M is simple, the seismic forces are directly proportional to the mass so the heavier a construction is, the more intense stress it will suffer. Mass is not a parameter that exclusively concerns the structural question. The overall mass of the building is strongly influenced by the technological choices made for the construction of the envelope, floors, and roofs. Regardless of the structural system, a building with vertical enclosing walls made of solid or semi-solid brick will experience greater seismic actions than one with an envelope made of lightweight prefabricated panels. In addition to the masses associated with the building's own weight, there are also masses that derive from its intended use. Even in this case, their distribution is largely a consequence of the designer's choice. The masses on the higher floors produce higher overturning moments, so it is not convenient to have spaces intended for libraries or large crowds on the upper floors.

PERIOD

Once a vibration motion of the construction has been triggered, the time taken to complete a complete oscillation is called the modal period T and depends only on the characteristics of the construction. More precisely, T , usually expressed in seconds, depends on the ratio between the overall mass and stiffness of the building. For the same mass, constructions with different periods will undergo actions of different intensity and the relationship between the period of the construction at maximum overall strength is described by the elastic response spectrum (**Fig. 1**). The spectrum provides, depending on the period, a fictitious acceleration (pseudo-acceleration) which can be interpreted as force per unit mass. The proposed summary can be brutal, and the safety assessment requires more refined analyses of the problem. However, the fact remains that mass and period are the two fundamental parameters that the designer has available to control the seismic response of his construction. Just as it is evident that these two parameters are already written in the construction system chosen for the building and that the outcomes in terms of seismic response are already defined in the initial moments of the design and conception of the structural system. Earthquake engineering today can guide the design towards solutions that provide the same level of safety even using different construction systems but heavy solutions with a short period, for example masonry constructions with few floors, must withstand larger actions and are at a disadvantage compared to lightweight solutions with longer vibration periods.

DISSIPATION: TRADITIONAL APPROACH

The movement of the building during an earthquake can be interpreted as a transfer of mechanical energy from the ground to the structure, as the energy enters the motion manifests itself with increasing intensity, at the end of the event the motion is reduced and the building stops after all the incoming energy has been dissipated. The amplitude of the motion that occurs and the associated stresses on the buildings are more limited the more the system is capable of quickly dissipating the energy that is entering. In the conventional approach to structural design, energy dissipation derives mainly from damage to the building, damage which initially involves non-structural elements (partitions, windows, etc.) and then reaches the structural components in the case of particularly intense seismic events. In this logic, the more a construction is capable of suffering damage without collapsing, the more it will be capable of dissipating energy, its motion will be more contained, the stresses will be moderate and the (initial) cost of the structure will be limited. Obviously, when the earthquake arrives, there will be a cost to pay to make the building functional again and this cost will be proportional to the damage. The owner is therefore faced with the alternative of choosing whether to spend more on the construction of a new building or risk spending much more on restoration in the event of an earthquake.

This aspect is described by the behaviour factor q . This factor starts from the unit value for structures designed not to be damaged and takes on gradually larger values based on the effectiveness of the damage mechanisms activated to dissipate the energy. This results in a reduction in the design seismic force as illustrated in (**Fig. 2**). In this way the structural design in a seismic area is made up of three phases: choice of the behaviour factor in relation to the structural type and level of damage accepted in seismic conditions, design of the structure with the seismic forces reduced based on q , implementation of all the detailed rules aimed at ensuring that the structure actually has the ability to dissipate seismic energy in a manner consistent with the adopted behaviour factor.

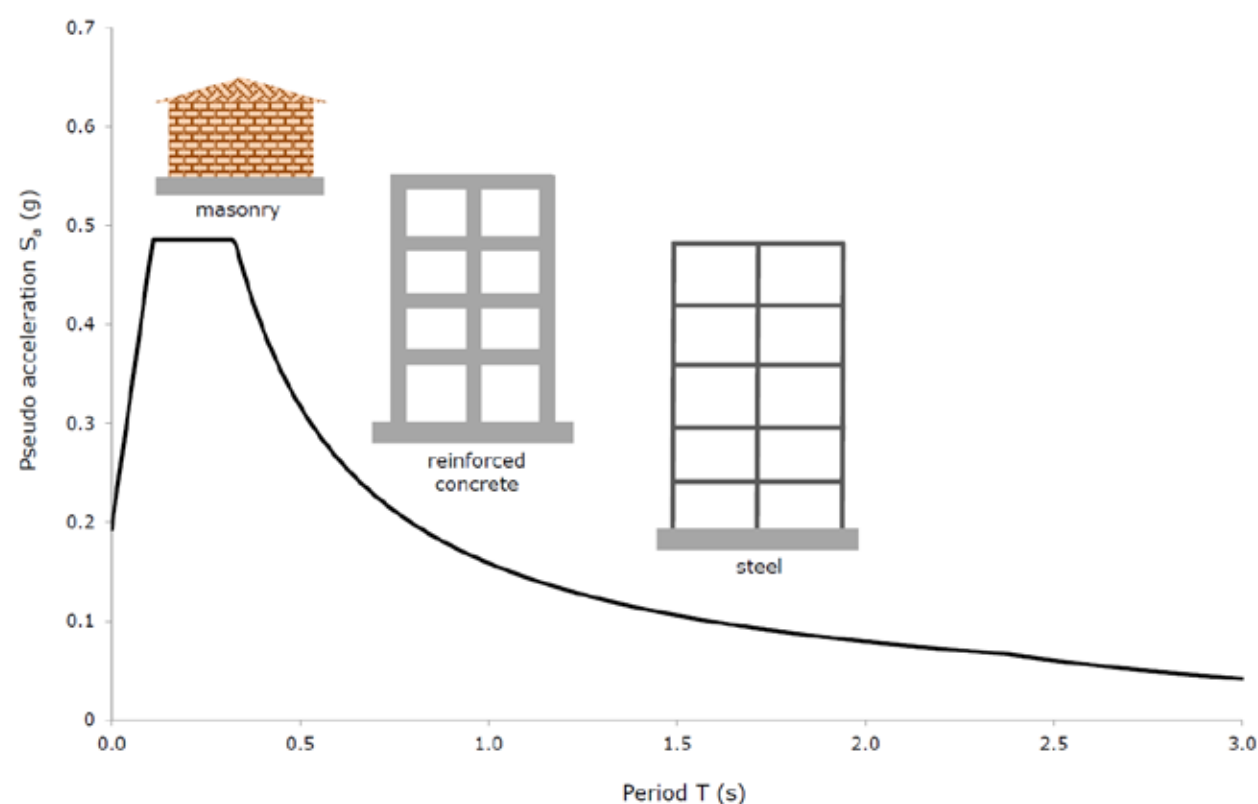


Fig. 1 Seismic action as a function of the construction period.

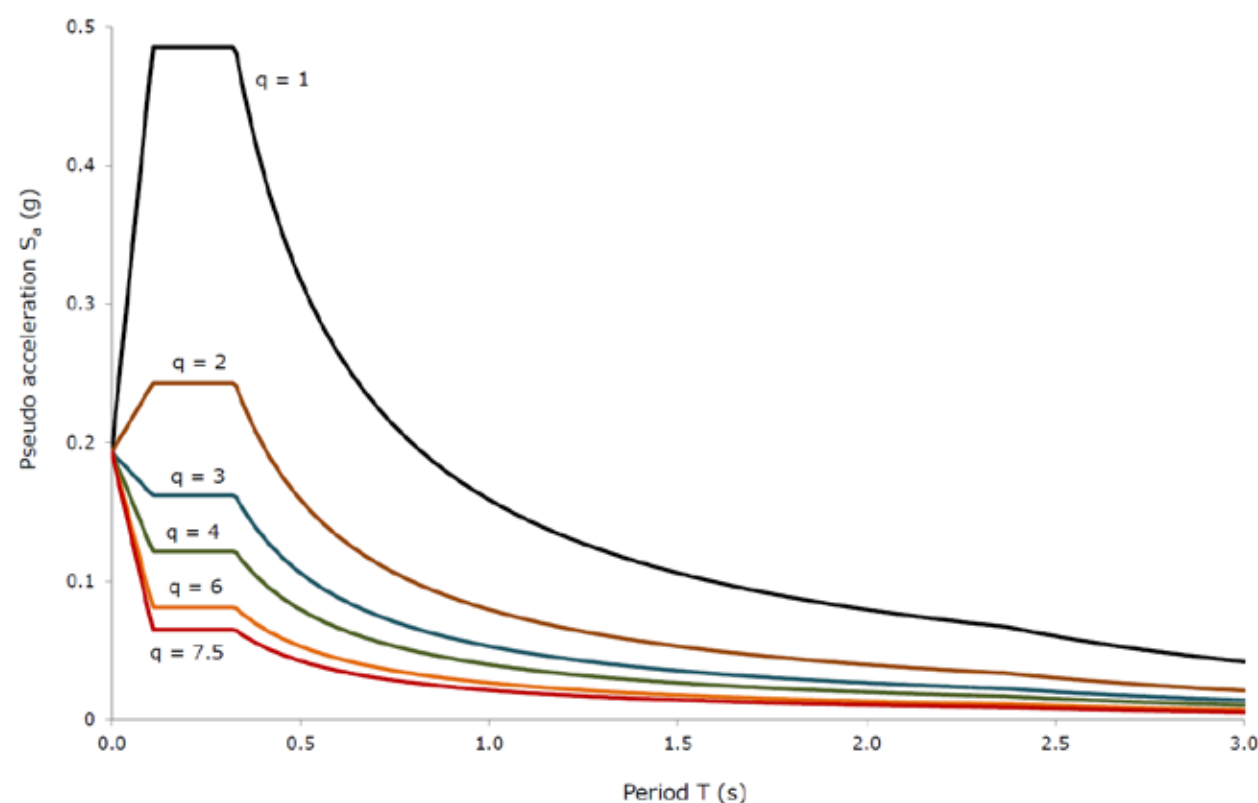


Fig. 2 Variation of the design seismic action with the behaviour factor.

DISSIPATION: ALTERNATIVE APPROACH

In recent decades, more rational and effective approaches have been applied to exploit dissipation, according to two different strategies. The first concerns the actual period of construction. As clear from the response spectrum (Fig. 1), if the building oscillates more slowly (longer period), the accelerations and seismic forces are significantly reduced. The result can be achieved by introducing a flexible system, called seismic isolation, between the foundation integral with the ground and the upper part of the building. The second strategy relies on dissipation and is implemented by introducing special devices, seismic dissipators, which dissipate the incoming energy, preventing it from causing damage to the construction. The two techniques can also be combined to optimize the overall performance.

Objective: seismic safety of existing buildings

Interventions on existing buildings are an increasingly important issue due to the aging of the buildings and infrastructures built during the decades of strong economic and demographic growth of the last century, often designed according to obsolete anti-seismic criteria or without considering seismic action because at that time the area in which they were built did not fall among those classified as seismic. Today it is well known that the entire Italian territory is subject to seismic risk and recent events have unfortunately highlighted the seismic vulnerability of buildings as a social and economic emergency that threatens both the lives of the inhabitants and production activities. For these reasons, the search for effective and competitive solutions to reduce the vulnerability of existing buildings to earthquakes has assumed roles of growing centrality in the construction sector.

Special considerations must then be made for that class of existing buildings constituted by historic and monumental buildings, an extraordinary heritage for Italy which needs to be safeguarded as a document of the country's cultural roots and enhanced for its major role in the economic growth circuit related to tourism. The deterioration of materials and the static concept often linked only to gravitational actions make historic buildings vulnerable to seismic action and require interventions capable of preserving their integrity, conceived, and carried out in the logic of restoration.

Methods for preserving architectural assets in seismic areas and ensuring their safety

In the context of interventions in existing buildings, it is necessary to distinguish between seismic improvement and seismic adaptation. In seismic improvement, the measures adopted make it possible to guarantee greater safety without significantly modifying the static scheme of the building and without achieving the performance required by the regulations for new buildings. The seismic adaptation intervention, however, requires that the structure be able to resist the same design loads required for new buildings. This could involve the massive alteration of the structural system and the radical modification of the building's response to seismic stress. National legislation specifies that it is possible to carry out improvement works in the event of a change of intended use, to eliminate design and/or execution errors, when the consolidation intervention is carried out on monumental buildings for which significant modifications are not acceptable. Seismic adaptation is instead mandatory in cases of raising or expansion of a building with an increase in volume and surfaces, increase in loads due to a change of intended use, substantial modification of the structural system following renovation interventions compared to the original or, in general, when the renovation involves an alteration of the overall static behaviour.

The planning of improvement or adaptation interventions requires a preliminary vulnerability analysis of the existing construction and the definition of the design objectives, establishing the performances required in case of seismic actions: limitation of damage to the systems and contents (control of absolute accelerations), limitation of damage to non-structural elements (control of relative displacements), safety against breakage (control of stresses and deformations), protection following a seismic event and replacement of damaged elements, feasibility and relationship between costs and benefits. Subsequently we proceed with the definition of the intervention strategy which may include an increase in ductility, dissipation, resistance, and stiffness. To achieve these increases in structural performance, one can generally proceed through interventions on the structural elements or through the insertion of extra-structural devices. A third way involves reducing incoming seismic energy through seismic isolation.

In the context of architectural heritage of historical and monumental value, the choice of intervention techniques is a much more complex question and is subordinated to the profound knowledge of the property in which the historical and evolutionary issues must be reconstructed by superimposing political-cultural and natural vicissitudes, the results of archival and iconographic studies, and those of geometric-architectural and material-structural analyses. Before choosing the materials, it is necessary to conceive the intervention aiming to promptly reduce or eliminate the recognized vulnerabilities, leaving the unaffected mechanisms unchanged, respecting the authenticity of the asset, limiting substitutions as much as possible and preserving the original materials with a complete visual inspection of the safeguards put in place. The intervention must be non-invasive, i.e. reversible, so that it can be maintained and replaced when new materials or technologies that are even less invasive than those used become available; the intervention must be carried out by evaluating the mechanical-structural and chemical-physical compatibility with the materials and construction systems of the architectural asset. The reinforcement systems can be conceived using traditional materials installed with techniques like the original ones or with innovative techniques, or using structural elements made with modern materials alongside or replacing degraded elements, to reinforce the weakened structure or to integrate the existing structure to eliminate the intrinsic vulnerabilities of the traditional system.

Having said this, the choice of materials and intervention techniques must be the most suitable for preserving the cultural value of the property. In a not-too-distant past, the use of Portland cement and structural concrete made us think of systems compatible with historic buildings, mostly made of masonry, until tragic events demonstrated not only the inability to preserve the construction but also the harmfulness of the use of these materials which are often incompatible also from a chemical-physical point of view. The insertion of reinforced concrete elements, in fact, as well as increasing the mass of the buildings, introduces evident structural discontinuities, capable of calling into question the balances necessary to guarantee the static nature of systems based on the frictional behaviour of the material.

Tools to preserve architectural assets in seismic areas and guarantee their safety

There are many technical solutions for interventions on built heritage to reduce seismic vulnerabilities and guarantee a sufficient level of safety. Among these, of particular interest is the use of dissipative bracings, adopted successfully in many seismic retrofit interventions of existing structures, as well as being integrated into many modern anti-seismic buildings. The braces can be inserted inside the frames of the existing structure with limited demolition and reconstruction interventions of the external infills and internal partitions, possibly supported by local reinforcements in the beams and pillars, or they can be left exposed (Fig. 3). This type of intervention determines an interruption in the use of the buildings subject to seismic adaptation limited in time and in the spaces involved. Dissipation can occur through elastoplastic systems based on the hysteretic behaviour of the steel when the yield force is exceeded, or through viscoelastic systems that exploit the dissipative properties of rubbers with high damping capacity. Given that we are often faced with existing structures with reduced ductility, a critical point in the design of such dissipative bracing systems is to guarantee the activation of dissipation for reduced lateral displacements, for example through kinematic displacement amplification systems.

An alternative solution that involves elastoplastic or viscoelastic dissipators is one that uses bracing systems external to the existing structure (Gioiella et al. 2018) as for example shown in (Fig. 4) or internal without interfering with its function as in the case of bell towers and minarets (Pavia et al. 2021). By adopting this solution numerous advantages can be obtained: the use of the existing structure is not interrupted as all construction and assembly operations do not involve the internal spaces, the existing foundations are not burdened by additional loads in static and seismic conditions, it is more simple to control the seismic behaviour as the project is not tied to the distribution of the internal spaces and is less influenced by the plan of the building. It is possible to integrate accessory functions into the external devices, such as safety stairs or connecting landings, or elements of architectural characterisation.

Steel can have structural uses beyond those of bracing, with multiple applications given by different points in its favour. The first point is certainly the almost complete reversibility of the systems which are installed prefabricated and anchored to the existing construction by means of contrast plates and contact elements. Tie rod systems made with high-performance steels are therefore widely used in devices designed to counteract the thrusts of arches and vaults in buildings of historical and archaeological interest. The second aspect is the possibility of creating systems to carry out specific tasks without altering the virtuous resistant



Fig. 3 Example of exposed dissipative braces in an existing structure.



Fig. 4 Example of an external trussed structure with seismic energy dissipation system.

mechanisms of the existing system (minimum intervention criterion). For example, building crowning curbs can be created to give the masonry the necessary attachment at the top (Fig. 5), encouraging the anchoring of existing elements, such as wooden trusses, so that they do not slip out of their housings and at the same time constitute a constraint against overturning of the walls, without adding significant masses and guaranteeing maximum flexibility with respect to the vertical movements which must be left free so as not to alter the tension states due to gravitational actions. Another significant example is the possibility of designing floor stiffening systems in detail, designed to guarantee membrane efficiency while interfering to a minimum with the tension regime due to vertical loads with minimum mass increases and conservation of existing horizons and coverages. The third positive aspect is the similarity between wooden and steel horizontal and roofing systems; while replacing a wooden floor with one in reinforced concrete is a rather invasive and harmful operation for an existing masonry construction, the replacement of wooden elements (beams and trusses) with similar steel elements, although questionable from a material point of view, is compatible from a construction and mechanical-structural point of view. Fourth positive aspect is the excellent performance ratio between mechanical characteristics and mass, fundamental in limiting the inertia of the systems. This makes the use of steel particularly suitable in the valorisation of historic buildings: the possibility of designing systems with reduced mass (in some cases compensated by the replacement of non-structural elements) and specialized behaviour to deal with specific actions (mezzanines, walkways, stairs) allows the insertion of structural systems capable of improving the usability of the property without altering its overall seismic behaviour and maintaining the visual permeability necessary to enjoy the features of the historic building. Fifth point of attention concerns the recognizability of the intervention. Finally, the chemical-physical compatibility of the material, once discussed due to its easy corrosion characterized by an increase in volume and leaks, is today overcome using galvanized or stainless-steel elements which can be used to repair damage to wall facings and connections.

The outlined framework cannot and does not want to be exhaustive of all the possibilities available to designers and builders to pursue the objective of seismic safety of buildings. However, we want to add a very particular solution to what has already been presented. Non-structural elements in general and furnishing systems in particular can constitute a source of further risk or possibility of unexpected protection in the

event of a seismic event. For example, a wardrobe can endanger the occupants of a domestic space if it tips over on them or constitute a survival cell if capable of protecting people who have sought shelter there. A multidisciplinary research project on this topic recently dealt with developing furnishing systems with a life-saving function in the event of an earthquake with specific reference to the school sector. Exploiting the ability to resist impacts and overloads of the various furnishing elements and their interaction and systematization, could provide the possibility of being able to secure spaces for which structural interventions are planned but not yet implemented or for those cases where interventions are significantly limited due to historical and monumental constraints (Fig. 6) shows a phase of the experimental evaluation of the protection capacity of a school desk following an impact such as that which would occur with a collapse involving a good part of the building (Gioiella et al. 2022). The capacity of the school desk could be further improved connecting adjacent elements with a metallic clamp that is easy to operate, as illustrated in (Fig. 7). Protection against damage of the partition walls and their potential overturning can be provided, for example, by properly designed shaving units, as those shown in (Fig. 8) designed according to specific seismic rules (Gioiella et al. 2022). Partitions could be redesigned to have dissipative properties when subjected to seismic excitations, as for example discussed in (Scozzese et al. 2024). The (Fig. 9) documents a pilot installation in a high school institution of the furniture system with a life-saving function which integrates interconnected desks to amplify the resistance capacity to possible collapses, desks, shelving units with an anti-tipping function of the walls and protection for students near it, partition walls with high damping rubber capable of dissipating energy without being damaged.

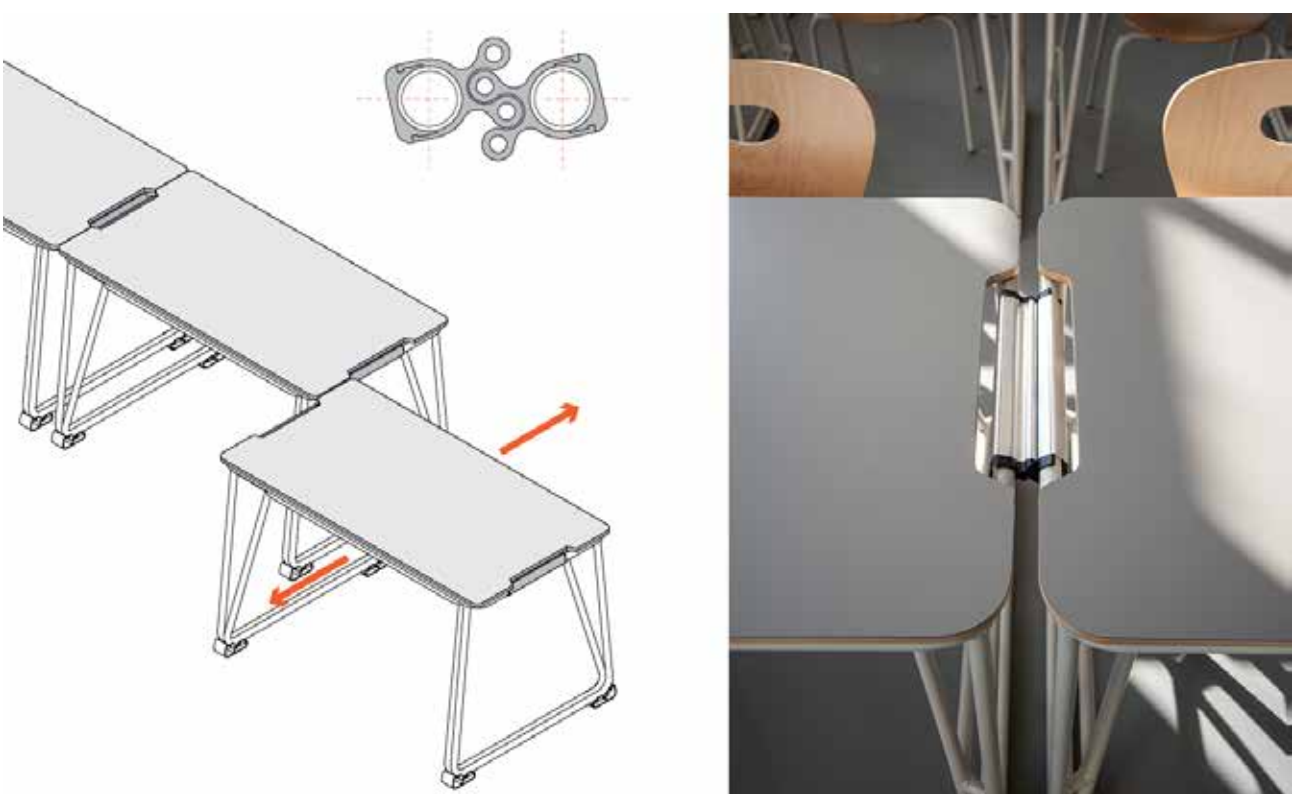


Fig. 7 Structural connection of adjacent school desks to improve life-saving capacity.



Fig. 5 Insertion of steel curbs in a historic masonry construction.



Fig. 6 Experimental verification of the protection capacity of a life-saving school desk under impact simulating structural collapse.

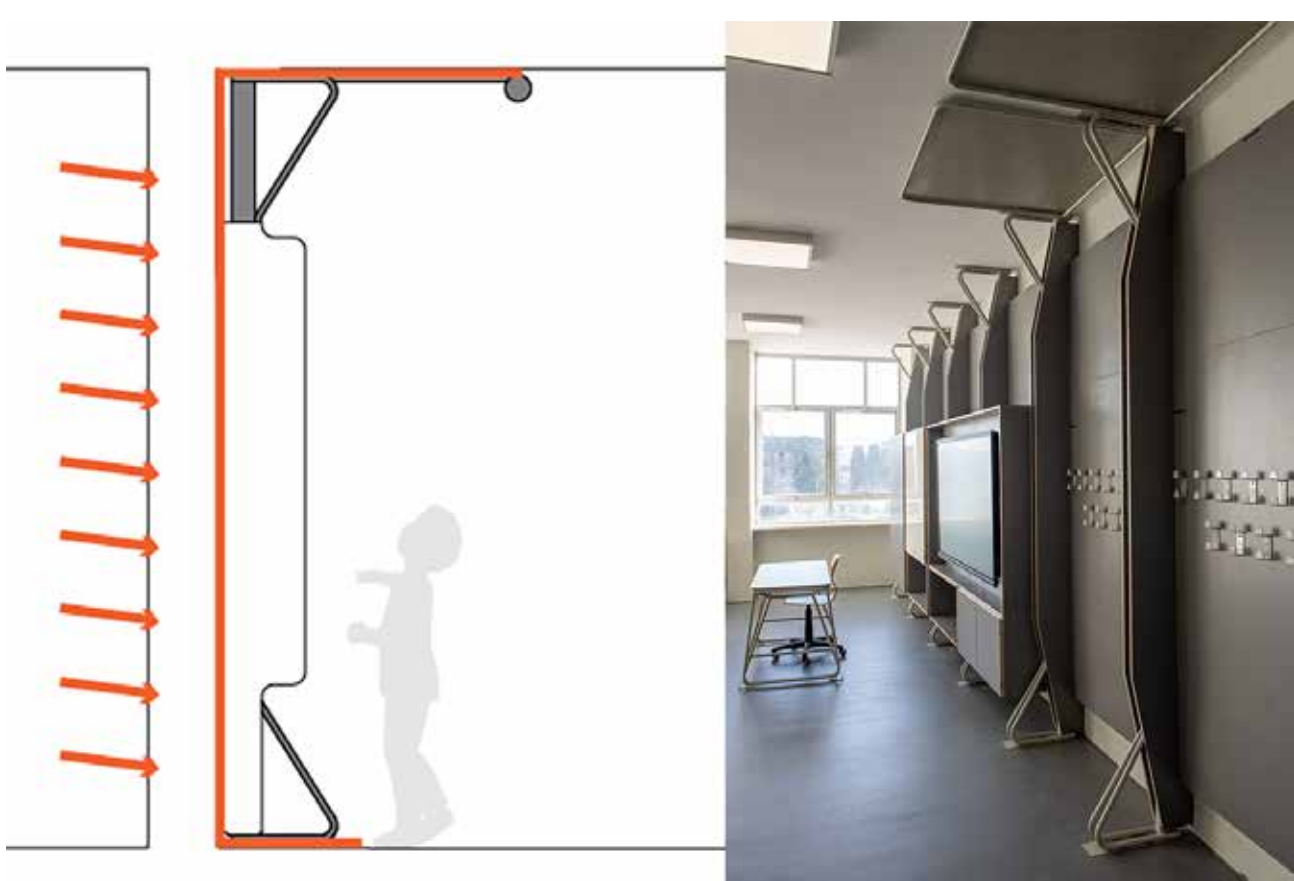


Fig. 8 Protective shelving unit with life-saving capacity.



Fig. 9 Pilot installation of furniture with life-saving functions in case of earthquakes

Conclusions

The objective of guaranteeing adequate safety of buildings against earthquakes is a complex problem and in general it is not possible to identify a single solution that can work in all cases, both in the design of new buildings and in improvement or seismic adaptation of existing buildings. Modern seismic engineering provides designers and builders with a wide range of knowledge and technologies which inevitably require properly trained people able to understand and use what is available, as well as guide the client towards the most suitable choice. As seen, it is essential to evaluate the costs for the entire life cycle of the construction, systematizing the initial costs and the costs of any repairs in the event of seismic events, remembering that the structural response in the event of earthquakes does not depend only on the structure but is influenced from all the (non-structural) elements that contribute to the mass and dissipation of the building. Seismic design must therefore inevitably involve all the actors who contribute to the conception of the building.

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OUTPUT AND FINAL REMARKS

Section

3

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All of the methods and instruments for participatory reconstruction of destroyed historic centres presented here have been developed and tested at pilot sites, in particular in the earthquake- ravaged town of Accumoli, and are generally available for use in similar contexts. We are well aware that simply providing the instruments and methods will not guarantee success in future reconstruction projects involving destroyed historic centres.

It is of fundamental importance to create structures that further develop these methods and instruments and disseminate their application. Specifically, it is necessary to communicate the use of these methods and instruments to lecturers, future planners and current students, but also to emergency services, government officials and politicians. Depending on the target group, different content priorities and emphases must of course be set.

For this reason, a curriculum similar in scope to a certified programme of 30 ECTS has been developed as part of this project, based on the experiences and results of the 'Learning and Teaching Activities'. Such a curriculum should be able to be integrated into regular study programmes as an advanced subject or offered independently as a postgraduate specialisation. Of course, the relevant country-specific study regulations must be taken into account. In most countries, there are few admission restrictions for such certified programmes, so that a very broad target group can be addressed.

The broad spectrum of methods and instruments is also characterised by the different disciplines on which they are based. This certainly poses a certain challenge in the implementation of the study programme. The second special feature is the close cooperation between academic institutions and the local population, local planners and authorities, and other stakeholders.

In any case, the project consortium will endeavour to hold project weeks, summer universities and study modules at the reconstruction school in Accumoli in the future to teach the basic content that serves as the basis for the methods and instruments for the participatory reconstruction process of historical urban structures. We also invite any interested partner institutions to cooperate with us in this matter. The project consortium is also happy to support other universities and organisations in implementing the study content on the methods and tools developed and tested in this project.

Of course, it is to be hoped that the need to reconstruct urban structures after man-made and natural disasters will hardly ever arise in the future. In the event of destruction, the results of the ComPaRe project may find wide application, thus proving their usefulness in future construction projects and providing valuable support to those affected and those responsible for taking action.

Author Biographies

Belmonte Carmen is an Assistant Professor in Museology, History of Art Criticism and Conservation at the University of Padua. Her research focuses on the visual and material culture of Italian colonialism, on the legacies of fascism, and on cultural heritage in post-disaster scenarios. After receiving her PhD in Art History from the University of Udine, she was a researcher at the Kunsthistorisches Institut in Florenz – Max-Planck-Institut, and at Roma Tre University. She was awarded postdoctoral fellowships from the Bibliotheca Hertziana – Max Planck Institute for Art History, the American Academy in Rome, and the Italian Academy for Advanced Studies in America at Columbia University, New York. She published the monograph *Arte e colonialismo in Italia. Oggetti, immagini, migrazioni (1882-1906)*, Marsilio 2021.

Bondini Saida is a postdoctoral fellow at the University of Zurich and the Kunsthistorisches Institut in Florenz – Max-Planck-Institut. She received her PhD from the Courtauld Institute of Art - University of London and the University of Lausanne (2021), where she also served as an Associate Lecturer in Early Modern Art. Saida has been awarded fellowships and internships by international institutions, including the Metropolitan Museum of Art, New York (2014); the J. Paul Getty Museum, Los Angeles (2020–2021); and the Italian Academy for Advanced Studies in America at Columbia University (2023–2024). Her current research project, funded by the Swiss National Science Foundation, investigates the interplay between art, architecture, and natural hazards in the early modern period, with a particular focus on historical earthquakes in the Mediterranean region.

Brownlee Timothy Daniel, Timothy Daniel Brownlee, architect and PhD, is a research fellow in Architectural Technology and Environmental Design at the School of Architecture and Design, University of Camerino. He conducts research collaborating on a number of international projects on the role and potential of outdoor urban space in relation to issues of public health and climate change adaptation (Interreg Joint_SECAP; Erasmus + CliCCHE; Life+ A_GreeNet project). He is professor at the Building Systems Laboratory in the 2nd year of Architectural Science, School of Architecture and Design. As an architect, he has developed experience on the topic of sustainability and energy efficiency working on aspects of environmental and technological design at different scales, outdoor urban space, residential and school design, development of commercial and museum spaces.

Caldarone Adriana is a researcher in the Department of History, Drawing and Restoration of Architecture at Sapienza University of Rome. She operates within the Scientific Disciplinary Sector CEAR-10/A (formerly ICAR/17) – Drawing. Her research activity focuses on a wide range of topics. In particular, her research interests include: surveying and understanding built heritage and landscape: this area explores techniques and tools for the representation and analysis of buildings and territorial contexts, with particular attention to their history and distinctive characteristics; the study of communication systems related to visual and extra-visual perception: this research line investigates how humans perceive, interpret, and represent the surrounding environment—through both sight and other senses—and how this perception is influenced by cultural and social factors; the development and use of ICT in the field of Cultural Heritage: based on the application of information and communication technologies (ICT) to the field of cultural heritage, with the goal of enhancing the conservation, management, and accessibility of artistic and architectural heritage; research in the field of BIM and HBIM, including the redefinition of an approach that simultaneously considers the built environment, the design process, and the model itself, aiming to shift toward a holistic approach that integrates the various dimensions of environmental sustainability and the value of buildings within BIM models.

Cognoli Roberto, architect and PhD, currently a Research Fellow and Adjunct Professor at the School of Architecture and Design E. Vittoria in Ascoli Piceno, University of Camerino (SAAD). His research primarily focuses on computational design and digital fabrication, targeting sustainability and circularity within the construction industry. He specializes in digital technologies such as mixed reality and robotic fabrication to develop reversible timber construction systems and the additive manufacturing of cement mixes with recycled aggregates. His expertise extends to the application of advanced digital technologies for designing adaptation solutions to climate change at both urban and building scales, aiming to enhance urban comfort and health. He has authored several publications that discuss the intersection of digital fabrication and sustainable

building practices. Additionally, he is a co-founder of an innovative startup dedicated to large-scale 3D concrete printing using recycled aggregates sourced from the demolition waste generated by the 2016 Central-Italy earthquake.

Drdácký Miloš has more than 30 years of practice in the cultural heritage research and planning and serves as Chair of the Council of the Czech Minister of Culture for Research and the Czech representative in the European Joint Programming Initiative Cultural Heritage. After twenty years as the director of the Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, he now serves as the head of the Department of Heritage Science. Miloš conducts research in the field of historical materials, structures and sites and his results has been published in more than 520 publications and reports, he has edited 27 books or conference proceedings. He participated in 30 international projects supported from the EC FP programs started the FP 5 or from the Interreg programs. In the field of cultural heritage research he was a member of an international research team awarded in 2009 with a EU Grand Prix and the “Europa Nostra” Award for the best European cultural heritage research. He has been interested in analysis of damage on built heritage, and research of cultural heritage resilience and sustainable conservation exploiting involvement of stakeholders especially in relation to preventive measures against impact of global threats.

Drdácký Tomáš, diploma engineer architect working at the Department of Heritage Science at the Institute of Theoretical and Applied Mechanics, Czech Academy of Sciences. He has a long experience as Mayor of Prague-Troja Municipal District, dealing with threats of both man-made and natural hazards. He was involved in several national and international research projects focused on problems of management of territories and historic towns, e.g. flood risks (CHEF), tourism and public participation (PICTURE, OPTURISM) and urban evaluation and planning processes (SUIT, NAKI II). He was an external lecturer at the CTU Prague, TU Liberec and the Czech University of Life Sciences. Tomáš Drdácký is an active member of ICOMOS - Czech National Committee as well as ICOMOS international Scientific Committees. He chairs the Steering Committee of the UNESCO World Heritage Site Historic Centre of Prague and participates in the Management Plan of the UNESCO World Heritage Site Landscape of Breeding and Training of Ceremonial Carriage Horses in Kladruby nad Labem.

Empler Tommaso (1965) is an Associate Professor in the Scientific Disciplinary Sector CEAR-10/A (formerly ICAR/17) – Drawing. He graduated with honors in 1992 from the Faculty of Architecture at Sapienza University of Rome. He earned his PhD in Survey and Representation of Architecture and the Environment in 1998, with a dissertation on the Information Model for Architectural Survey. Since 2015, he has been the Director of the 3D Modeling & BIM Workshop, which reached its 10th edition in 2024. Since 2020, he has been the Director of the Master's Program in Heritage, Building Information Modeling (HBIM) at Sapienza University of Rome. Since 2017, he has served as the Editor-in-Chief of the journal Dn. Building Information Modeling, Data & Semantics.

His research topics include: issues related to accessibility and Universal Design; advanced forms of digital representation for both design and surveying purposes, with a particular focus on the development of Open Source applications; the study of communication systems related to visual and extra-visual perception; the development and use of Information and Communication Technologies (ICT) in the field of Cultural Heritage; topics related to HBIM and Digital Twin processes.

Foletti Ivan is full professor at Masaryk University and privatdozent at the University of Helsinki. He received his PhD degree in art history from the University of Lausanne 2010. He specializes in investigating the History of Art History and the art of Late Antiquity, Early Middle Ages around the Mediterranean, and Russian art. He is the head of the Center for Early Medieval Studies (Brno), director of the international journal *Convivium* and of the Hans Belting Library. He taught as invited professor at the universities of Bologna, Fribourg, Helsinki, Lausanne, Naples, Padua, Poitiers, Prague and Venice. He is author of eighth research monographs e.g. *From Byzantium to the holy Russia*, Rome 2017 [2011] and, *Russian Imperialism and the Medieval Past*, York 2024 [2023]. He was awarded with Prize of the Faculty of Arts (Lausanne University, 2011), Josef Krása Award (2016), Order of second degree (Czech ministry of education, 2018), Prize of the South Moravian Region (2019).

Hain Vladimír graduated from the Faculty of Architecture at STU in Bratislava (since September 2020, the Faculty of Architecture and Design – FAD STU) in 2011. Since his doctoral studies in Architecture and Heritage

Restoration, he has been dedicated to digital technologies, their application in architecture, and particularly the presentation of industrial heritage.

He has actively participated in numerous international conferences and has served as a co-organizer and curator of several exhibitions. His research has been published in specialized journals, and he has taken part in architectural and urban planning competitions, receiving multiple national and international awards in collaboration with his colleagues. In 2024, he was a member of the Organizing Committee of the Conference on Engineering and Architecture Design Education (EADE-2024) and a member of the Scientific Committee of the International Scientific Conference "Rethinking Industrial Routes and Networks," organized by TICCIH Serbia in Novi Sad.

Hajtmanek Roman, PhD. graduated at the Faculty of Architecture, Slovak University of Technology in Bratislava (STU), in 2016 as well as at the University of Applied Arts in Vienna, in 2018, gaining his master's degrees in architecture. In 2019 he finished his doctoral studies at the Faculty of Architecture and Design, Slovak University of Technology, receiving his PhD degree. His work has been published in several publications, competitions and group exhibitions. He has worked for several architectural studios based in Vienna and Bratislava. Currently he is a researcher at the Faculty of Architecture and Design, focused on experimental applications of virtual reality and machine learning in architectural domain. He teaches at the Institute of Ecological and Experimental Architecture and at the computational design studio Data[LAB].

Hanáček Tomáš, PhD. graduated from the Faculty of Architecture and Design, Slovak University of Technology in Bratislava (STU) in the field of Architecture in 2020. He is currently a PhD student at the Faculty of Architecture and Design, Slovak University of Technology. He teaches at the Institute of Ecological and Experimental Architecture and at the design studio Data[LAB]. His work focuses on parametric design, fabrication, manufacturing, virtual and augmented reality and 3D modelling. His doctoral studies are focused on the topic of breaking the barriers in education and intuitive using of computational tools in the creative process. Currently he is also a part of light design and digital art studio CTRL_space.

Jakubec Ondřej is full professor of art history at Masaryk University in Brno and Palacký University in Olomouc. He works on the early modern visual culture in central Europe, especially with regard to the issues of history of architecture, art patronage, religious and confessional identity, sepulchral cultures, and cultures of commemoration. He is author of *Kde jest, ó smrti, osten tvůj? Renesanční epitafy v kultuře umírání a vzpomínání raného novověku* [Where Is, Oh Death, Thy Thorn? Renaissance Epitaphs in the Early Modern Culture of Dying and Commemorating], 2015), Telč: The Historic Centre, 2013 (with Jiří Kroupa), editor of *Central European and American Perspectives on Visual Arts in Early Modern Europe*, 2013; *Karl von Lichtenstein-Castelcorneo (1624–1695): Bishop of Olomouc and Central European Prince*, 2019; and coeditor of *Olomoucké baroko: Výtvarná kultura 1620–1780* [Olomouc Baroque: Visual Culture, 1620–1780], 3 vols., 2010–11) and *Central Europe as a Meeting Point of Visual Cultures: Circulation of Persons, Artifacts, and Ideas*, 2021.

Kroftová Klára is an associate professor at the Czech Technical University in Prague - Faculty of Civil Engineering, Department of Architecture. She acts as an expert guarantor and head of a number of courses, including studios, within the study focus "Preservation and Restoration of Monuments" and is an expert guarantor of the doctoral study programme Architecture and Sustainable Development. Her academic and teaching activities also include collaboration on various research projects, educational programs and workshops focused on historic structures, restoration and conservation. She is the author and co-author of 4 books on urban tenement houses, more than 90 articles in professional journals and papers at international conferences and curator of the exhibition "Traditional construction during the time of Emperor Franz Josef" at the CSD NTM in Plasy (2022-present).

Losco Giuseppe, Architect and PhD, is a Full Professor in Industrial Design, former Director of School of Architecture and Design of University of Camerino. Cultural and scientific interests have focused on the design process and its central role in phases of the construction and industrial process. The research has become a place for experimental design aimed at new models of green environmental development and new concepts product, with production sectors of other disciplinary areas. The research has addressed the aspects of innovative materials and technologies for the qualitative development of the built environment, with reference to the use of eco-sustainable and energy-efficient materials, techniques and technologies for energy saving.

Morgenstein Peter, Ph.D. (male) is a researcher and since 2013 a member of scientific staff at the Krems University for Continuing Education, Austria. Since 2023 he is part of the Research Lab for Sustainable Architectural Heritage. Between years 2013 and 2023 he has worked in the Department for Building and Environment leading the Centre for Architectural Heritage and Infrastructure from 2016 until 2018. Since 2013 he has also been working as researcher at the Institute of Ecological and Experimental Architecture at the Faculty of Architecture and Design, Slovak University of Technology in Bratislava. He graduated in architecture from the Slovak University of Technology in Bratislava, Slovakia, where he has also finished his doctoral studies by defending his dissertation thesis titled: Typology of Solar Town Planning: Energy Cooperativeness of Urban Structures. From 2018 to 2022 he worked at the Faculty of Architecture and Design in the position of vice-dean for international relations and development.

Palladino Adrien is an assistant professor at Masaryk University in Brno, Czech Republic. He completed his PhD in 2019, conducting his research between the University of Fribourg (Switzerland) and Masaryk University. His doctoral dissertation, later published as *Inventing Late Antique Reliquaries* (Rome: Viella, 2022), explores his primary focus on the material culture of the Late Antique and Early Medieval periods. Palladino also examines how research, musealization, and restoration efforts from the 18th to the 20th century were impacted by contemporary political, religious, and cultural contexts. He has held fellowships at the Bibliotheca Hertziana – Max Planck Institute for Art History in Rome, the Deutsches Forum für Kunstgeschichte in Paris, the CUNY Graduate Center in New York, and the Département des Arts de Byzance et des Chrétientés en Orient at the Louvre. Since January 2024, he is PI for the project *Dreaming Byzantium in Nineteenth-Century France*, funded by the Czech Science Foundation for three years.

Pasqualini Chiara, Architect, is a PhD Candidate in Innovation Design at SAAD, University of Camerino (Italy). Graduated with honors, she has worked with several private architecture firms on renovation projects and with the Municipality of Osimo during the revision of the Master Plan. Her research explores the topics of buildings energy efficiency and energy management, circular and renewable energy supply strategies for the communities, digitization of buildings through Building Information Modeling (BIM) and energy analysis and simulation through Building Energy Modeling (BEM). Her doctoral research, in collaboration with a large multinational manufacturing Company, investigates the themes of energy and digital transition towards the decarbonization of industry.

Perger Josef born in 1954 in Mitterkirchen on the Danube. Studied at the University of Innsbruck. Doctorate (1985) and habilitation (1996) in the field of 'Theories of Knowledge'. This was followed by research projects and subject-specific teaching, preferably in the area of knowledge content that is difficult to communicate (e.g. in the sense of tacit knowledge in the research of Michael Polanyi). Both were carried out in co-operation with experts in educational science, philosophy and comparative literature at the Universities of Innsbruck and Bolzano. From 1998, establishment and further development of the Drafting and Design course into a Master's programme open to craftspeople; from 2011 in close cooperation with Danube University Krems. In this context, winner of the 2014 Prize of the Bündner Kunsthandwerk Foundation. From 2005 to 2021 member of the research team at the Caminada Chair at ETH Zurich. Responsible for the linguistic version of architectural projects, discussion of basic questions of architectural theory and methods of communicating central ideas within architectural projects. This activity is maintained in a slightly different form in the form of contributions to the architectural office of Gion A. Caminada, Vrin, Graubünden. Before and alongside the academic assignments, part of his commitment flowed into practical work. From 1974, he worked as a student trainee in an automobile factory and later in several relevant workshops. From 1996 the interest changed to

Picci Arianna holds a degree in Architecture; she graduated in 2024 in Architecture (Restoration) from Sapienza University of Rome with a thesis titled "Procedura HBIM su un borgo colpito dal sisma del 2016; caso studio di Accumoli e Terracino (Accumoli)." She is interested in the application of the BIM and has explored this methodology for the restoration of built heritage in the post-earthquake context.

Pompeo Esterletizia Architect and PhD student in Representation within the PhD program in History, Representation, and Restoration of Architecture at Sapienza University of Rome. Works as a tutor for the

courses of HBIM Model and Descriptive geometry fundamentals and applications and as Professor at HBIM II Level Master.

Her research interest primarily focus on digital methodologies to model architectural surface morphology and develop strategies throughout the integration of survey and BIM procedure for the communication and preservation of cultural heritage.

Ruggiero Roberto, architect and PhD, is Associated Professor at the School of Architecture and Design, University of Camerino, where is responsible for the B_lab (Building system laboratory) and the BB_lab (Bachelor Building system laboratory). He is responsible for the SaadLab Prototype, a university fab-lab equipped with digital manufacturing technologies and a member of the PhD International School of Advanced Studies of the University of Camerino. His teaching and research activities are focused on different topics, among them: technological culture of design, building systems in the area of housing, digital innovation for circular building, design processes for emergency areas. On those topics, he is member of international research groups and author of several publication.

Scirocco Elisabetta is a permanent researcher at the Bibliotheca Hertziana – Max Planck Institute for Art History, Rome. After receiving her Ph.D. in Art History from the University of Naples Federico II, she has been a postdoctoral researcher and collaborator at the Kunsthistorisches Institut in Florenz – Max-Planck-Institut, the University of Naples Federico II, and the Max Planck Institute for Human Development in Berlin. Her research interests and publications focus on medieval and early modern art and architecture in Southern Italy, on digital art history, and on the relationship between natural disasters and cultural heritage.

Sordilli Giulia, a graduate in Architecture (Restoration) from La Sapienza University of Rome, has focused on the application of HBIM (Heritage Building Information Modeling) for the conservation and restoration of villages affected by the 2016 earthquake. Her thesis, titled "Procedura HBIM su un borgo colpito dal sisma del 2016; caso studio di Accumoli e Terracino (Accumoli)," defended in 2024, concentrated on the case study of Accumoli and its frazione Terracino, examining how HBIM can support the documentation and recovery of damaged architectural heritage.

Stark Martin, Ing. arch., Ph.D. Licensed architect, member of the Czech Chamber of Architects, publicist, and teacher and researcher at the Department of Architecture at CTU specializing in sustainable architecture. He is also a Czech Passive House Centre lecturer and an elected city council member. He is a graduate of the Architecture and civil engineering program at the Faculty of Civil Engineering where he also received his doctoral degree on Application of Modern Shading Elements on 19th century Residential Buildings - Assessment of Indoor Overheating and the Impact of Additional External Shading on Visual Perception of Original Facade Composition.

Uhrík Martin, PhD graduated at the Academy of Fine Arts in Bratislava in 2001 and received his PhD degree at the Faculty of Architecture, Slovak University of Technology in Bratislava (FA-STU) in 2006. He was visiting scholar at the School of Architecture and Conservation, Columbia University in the USA and has been working with several internationally acclaimed institutions. He is the author of the book entitled Digital Architecture. Currently, he is an associated professor at the Institute of Ecological and Experimental Architecture at the FA-STU conducting classes in computational design studio - Data[LAB]. His professional practice is based on research in architecture that bridges the boundaries of other fields of study. The scope of his academic work is broad and consists of lecturing, research, publishing, architectural design, industrial design and computational form of computer driven design.

Currently, he works as a University Associate Professor at the vertical studio Data[LAB] and teaches the courses Constructions I, Constructions II, and Architectural Detail. He is also the course guarantor for Architecture and Mixed Reality and the Monument Restoration Design Studio at FAD STU.

His expertise in Mixed Media presentations and digitalization was further developed through a one-year Erasmus study program at Hogeschool voor Wetenschap & Kunst in Ghent, Belgium, as well as in cooperation with Design Factory n.g.o.. He was a speaker at the 5th and 6th annual international professional conference BIM and Digitization and, in 2017 he actively participated in VR EXPO in New York.

Urland Andrea, MA, PhD., is Associated professor at the Institute of History and Theory of Architecture and Monuments Preservation of the Faculty of Architecture and Design of the Slovak University of Technology in Bratislava; she also founded and leads the Colour Laboratory. Her research focuses on restoration of architectural heritage and colour in architecture and the urban environment. She has rich experiences in international professional training. She is author of numerous scientific publications, articles, a book and author of colour plans and designs.

Vošková Katarína Terao, MA PhD., is scientific researcher of the Institute of History and Theory of Architecture and Monuments Preservation, Faculty of Architecture and Design of the Slovak University of Technology in Bratislava; dedicated to the research and education in the field of restoration and presentation of architectural heritage; scientific coordination of the restoration works of the Banská Štiavnica Calvary from 2007; an author of numerous of the scientific and science popularization articles, professional publications and books; editor of the publications, books and monographs.

Wolf Gerhard is a scientific member of the Max Planck Society and Director at the Kunsthistorisches Institut in Florenz – Max Planck Institut. He is a member of the Berlin-Brandenburg Academy of Sciences and Humanities since 2009. From 1998 to 2003 Gerhard Wolf held the chair of art history at Trier University. Numerous guest professorships took him to Basel, Berlin, Buenos Aires, Cambridge Mass., Chicago, Lugano, Paris, Mexico City, Istanbul, New Delhi, Zurich, New York and elsewhere. His research interests and projects include: Global and transcultural art histories; image and object theories and practices; art histories, catastrophes, ecologies and heritage.

Zona Alessandro is a Professor of Structural Engineering at the University of Camerino, Italy. He obtained his 5-year Laurea degree in Civil Engineering summa cum laude in 1999 (University of Ancona) and his Doctoral Degree in Structures and Infrastructures in 2003 (Marche Polytechnic University). In 2003 and 2004 was a Researcher at the University of California San Diego, Department of Structural Engineering. In 2005 joined the University of Camerino as a tenure-track faculty member. In 2010 was a visitor at The University of Sydney, School of Civil Engineering. His research interests include: modelling and numerical simulations in structural engineering; seismic design of structural and non-structural components; experimental analysis of bridges, buildings, and infrastructures.

This book addresses the holistic, interdisciplinary and participatory approach to reconstruction processes following natural or man-made disasters. It results from three years of research and collaborative activities (2022-2025) conducted within the COM.PA.RE. project, winner of the European Erasmus Plus Call 2021, KA2KA220-HED, focused on cooperation partnerships in higher education. The initiative involves eight European partners, including university departments and research centers: University for Continuing Education, Krems (Austria); Slovak University of Technology, Bratislava (Slovakia); University of Camerino, Camerino (Italy); University of Technology and Economics, Budapest (Hungary); Masaryk University, Brno (Czech Republic); University La Sapienza, Rome (Italy); Czech Technical University, Prague (Czech Republic); Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, Prague (Czech Republic).

History indicates that reconstruction is often a complex and laborious process with uncertain outcomes. In current discussions, management and safety aspects, particularly related to natural disasters, tend to dominate public debate and media representations. This focus can overshadow a broader perspective that emphasizes the environmental, social, and individual imbalances that such traumatic events inflict on affected communities.

COM.PA.RE. aims to promote a design culture that prioritizes the restoration of values and communities before focusing on physical structures, such as homes. The book includes a variety of content, featuring narratives about reconstruction events from different geographical areas represented by project partners. It also shares experiences and experiments conducted within the project and highlights primarily digital operational tools. Overall, the volume serves as a resource on a holistic project culture centered on reconstruction and as a training manual for emerging designers.



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