

## Article

# Integrated Strategies for Preserving and Enhancing the Historical Heritage of the University of Pavia

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**Abstract:** The University of Pavia owns an extensive real estate portfolio, largely consisting of historic buildings still hosting teaching and research activities. This implies a continuous challenge in keeping them efficient, sustainable and completely usable. Indeed, these heritage buildings, alongside an undeniable charm, bring with them deficiencies regarding safety, accessibility, energy efficiency, etc. This work presents an interdisciplinary strategy addressing the issues involved in the management of the multiple needs of conservation and use, complying with modern standards. The legal requirement of a seismic safety assessment was the occasion to launch a comprehensive review of the state of the University building heritage, considering together the different aspects involved, in a perspective of economic sustainability, combining preservation needs and valorisation. The steps of this strategy included a preliminary screening of all the buildings, by simple methods and tools. The aim was to gather homogeneous and comparable information, useful to identify critical structures and/or repeated issues, to allocate resources for deeper analyses and implementation. The case study of San Felice Palace, which presents emblematic features and deficiencies, is illustrated in more detail, with complete seismic safety and accessibility analyses leading to proposals of enhancement interventions.

**Keywords:** cultural heritage buildings; integrated strategy; seismic assessment; accessibility; maintenance; valorisation



**Citation:** Greco, A.; Giacometti, V.; Rota, M.; Senaldi, I.E.; Penna, A. Integrated Strategies for Preserving and Enhancing the Historical Heritage of the University of Pavia. *Sustainability* **2021**, *13*, 783. <https://doi.org/10.3390/su13020783>

Received: 22 November 2020

Accepted: 7 January 2021

Published: 14 January 2021

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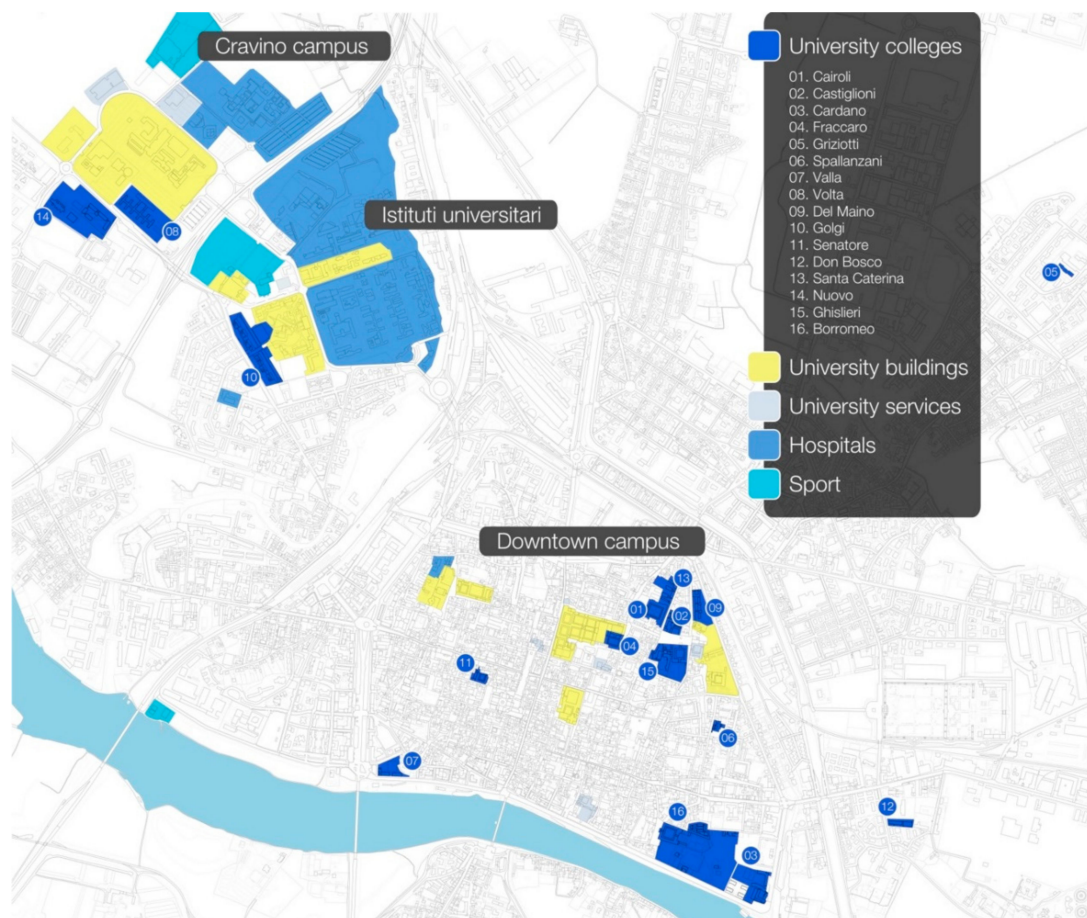
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## 1. Introduction

This paper illustrates an interdisciplinary assessment strategy applied to a portfolio of heritage buildings of the University of Pavia. The developed methodology aims at managing deficiencies of historic buildings with respect to sustainability and modern usability requirements and combining them with preservation and valorisation needs.

The University of Pavia is one of the oldest Italian (and European) Universities. With its 660 years of history, it has a large building heritage, spread throughout the city, distributed in three main centres (Figure 1):

- the downtown campus, where the Human Science and Economics Departments and the most important Administrative Offices are located; these historical buildings have a high cultural value and they are listed as heritage buildings, so that every intervention needs an authorization by the Department of National Heritage and Cultural Activities;
- the “Istituti Universitari” campus, where the Departments of Chemical and Physical Sciences and the Medical Institutes (built between the 1930s and 1970s) are set; this area is located northwest of the town, near the main communication infrastructures (railway and bus station, northwest ring road) and the health centres of the city (three “IRCCS” hospitals—Policlinico S. Matteo, Mondino Foundation, Maugeri Foundation—in addition to the CNAO, the National Centre for Oncological Adrotherapy);
- the Cravino campus, where the scientific departments (Engineering, Maths and Earth Sciences) have been located since the 1980s, bordering the countryside.



**Figure 1.** Map of Pavia, with university buildings, colleges, medical structures and university sport facilities. Scale 1:20,000.

This building stock daily hosts an academic community of over 25,000 persons, divided into students (22,500), professors and administrative staff (2500), and random visitors attending different events (conferences, meetings, concerts, graduation sessions, etc.).

The three campuses make up a heterogeneous heritage, with different needs for their conservation and operation. The maintenance and updating to the new research and didactic demands are a challenge that has to be faced with a multidisciplinary approach, working on different layers but with a holistic vision of the building and of the system in which it is set.

As a matter of fact, this huge built heritage realized over about eight centuries (it is believed that the northern part of the Central Palace—the main building of the university—already had its present conformation before being assigned to the university by Ludovico il Moro, at the end of the fifteenth century), presents a series of different needs, depending on the construction period and the hosted function; for example, the downtown campus has problems of accessibility and usability (since the buildings were built in a period in which persons with disabilities were no considered at all), while the buildings of the last century need energy efficiency optimization, just to mention one of the major problems.

In any case, the intervention cannot be separated by an in-depth knowledge of the actual building characteristics (materials, structural details, technological installations, etc.) and by a planning of interventions. The knowledge of the building is necessary to identify potential and critical issues in order to satisfy the academic needs. The planning of interventions is useful to ensure the continuity of the research and didactic activities of the different campuses.

In recent years, the university has set up a series of activities firstly aimed at adapting the existing heritage to the new teaching and research needs. Different projects were developed pursuing the principle of a sustainable development and the enhancement of the

cultural and historic value, combining the renovation and redevelopment of real “pieces” of the city to comply with new regulatory requirements regarding safety, accessibility and usability.

In this context, two topics were developed by a multidisciplinary team: the assessment of the seismic response of historical masonry buildings and their accessibility, considering the new approach for an inclusive society.

The first topic is of great interest both in the scientific community [1–3] and in the engineering practice, since masonry buildings constitute the large majority of the existing building stock in the Italian historical centres, and of course in the downtown campus of the University of Pavia. The structural assessment of these buildings, in particular in case of cultural heritage buildings, is strongly affected by significant uncertainties regarding construction details, level of connection and restraint among structural elements and variations in the static configuration occurred over the time.

Several methods for the seismic vulnerability assessment of heritage unreinforced masonry buildings have been proposed in the last decades, to investigate their structural behaviour both in-plane and out-of-plane. Such methods range from simplified approaches based on structural macro-elements, limit analysis, discrete element (DE) method and micromodelling or macromodelling based on the finite element (FE) method (an exhaustive state-of-art review is given, for example, in [4–8]). Procedures for the study of the seismic vulnerability of unreinforced masonry aggregates, typical of historical centers in Italy (within which heritage buildings are often located), have also been recently implemented [9–12].

Numerous applications of the aforementioned assessment methods are available in the literature (e.g., [13–23]). Nevertheless, such case studies are mostly focused on the study, and in some cases the strengthening, of the structural response of the heritage buildings without taking into account other aspects such as the enhancement of their usability or accessibility. Foster [24] has, for instance, underlined the importance to consider the positive environmental impact of an adaptive reuse of cultural heritage buildings to extend their lifecycle span, possibly operating in a circular economy framework.

The accessibility topic is becoming more and more important in the cultural heritage, according with the UN Convention on the rights of persons with disabilities (2006) that recognizes the right to education (art. 24) and to the participation in cultural life (art. 30). Likewise, the improvement of the accessibility and usability for people with disabilities or special needs in case of historical buildings is fundamental to preserve and valorise the existing heritage. In this case, an objective assessment is necessary to properly identify problems and select the best architectural solutions to solve them. The qualitative and heterogeneous methods have to give way to objective and homogeneous assessments allowing for the comparison between different options.

As a case study application, this paper presents the seismic safety and the accessibility assessment of one of the most important buildings of the historical heritage of the University of Pavia, San Felice Palace. The work underlines the importance of considering these two aspects (seismic safety and accessibility) simultaneously, as two fundamental projects key to preserve and enhance the built heritage. Too often, in both the national and international panorama, these aspects are instead considered separately, without a real design overview.

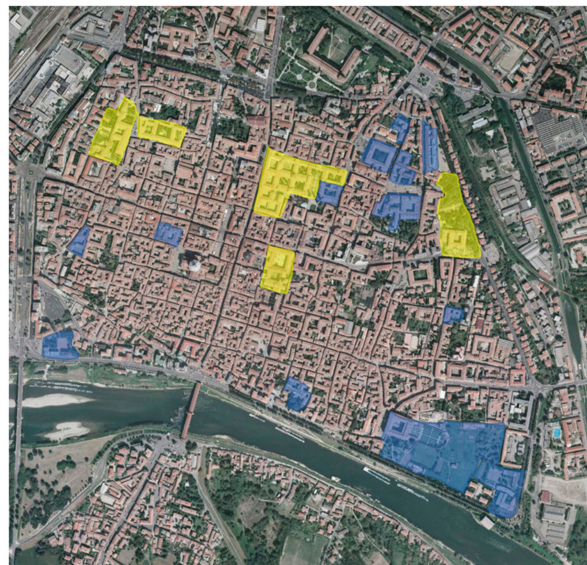
## 2. Heritage Buildings of the University of Pavia

The building stock of the University of Pavia consists of 52 buildings, for a total surface of approximately 250,000 m<sup>2</sup>. Fourteen of these buildings are considered as cultural heritage assets and, together with the university colleges managed by other public and private bodies, constitute an important part of the historic centre of Pavia (Figure 2), characterising its identity of university town.

A large part of this asset is used nowadays for teaching and research activities, hosting classrooms, departments, libraries and administrative offices. This implies high management costs, also due to the difficult compatibility of modern technological systems, their



limited efficiency and the need to satisfy strict safety rules for the use of the buildings, which are difficult to apply in the context of complex historical buildings.



**Figure 2.** Map of the historic centre of Pavia with evidence of the heritage university buildings (yellow) and the university colleges (blue). Scale 1:10,000.

The management, the maintenance and the conservation of this heritage is entrusted to a technical office that works under the Academic Governance direction. During the last years, the governance strategies have been oriented in three main directions:

- large works (a new building and complete renovation of a large historic building);
- safety interventions (structural and seismic, fire, etc.);
- sustainability and energy efficiency, together with improving the spatial and functional quality.

Due to the complexity of the building heritage, the technical office usually asks the collaboration of the researchers of the 18 departments of the university. The academic expertise is useful to develop projects able to respect and to valorise the built heritage and to find the best answer to the academic needs.

So, the Natural History Museum (KOSMOS) inside the Botta Adorno Palace was developed with a contribution by the Department of Civil Engineering and Architecture and the Department of Economics and Management; and the renovation of the Vistarino Palace, which became a location for conventions and a guesthouse, started from a survey and analysis developed by a group of researchers of the Department of Civil Engineering and Architecture.

The need of combining multiple functions in historical buildings (often not realised for academic function) requiring specific care for their conservation is for sure a challenging task, which is nevertheless necessary to guarantee their economic sustainability, through adequate valorisation and promotion.

In the last decade, other structural and technological renovation interventions have been started (e.g., San Tommaso Palace, Humanities Department and Library), strongly aiming at sustainability, energy efficiency, safety and usability. Furthermore, census and classification policies of the building stock have been launched, to identify possible issues related with structural safety, fire safety and accessibility.

In this context, an analysis of the building stock of the University of Pavia was carried out within the project SICURA, funded by the CARIPLO Foundation, aiming at identifying existing issues in the cultural heritage assets and at providing a scientifically sound database, to be used for a rational planning of ordinary and extraordinary maintenance, according to the principles of predictive maintenance and scheduled conservation.



### 3. Integrated Strategy for Building Assessment and Enhancement

The integrated strategy developed within the SICURA project aims at obtaining, on one side, a rationalization of the management costs of the real estate by means of innovative technologies and of the maintenance interventions; on the other side, it aims at an efficient multiyear planning of interventions, which need to be compatible with the conservation requisites and to provide a joint performance improvement of the different aspects of safety, energy efficiency and accessibility.

For each building, it is necessary to organize the information obtained from archival research, surveys, modelling, diagnostic tests and monitoring. The instruments used to collect this kind of information include simple archiving, dedicated computer tools (e.g., Archibus) or more advanced and versatile integrated systems, as the Geographic information system (GIS) and the Building Information Modelling process (BIM), allowing to manage information and issues related to different aspects (structural and non-structural damage, seepage, facilities, furnishings, barriers).

The seismic risk screening of the entire building stock of the university started from filling a form for each building and deriving a preliminary estimate of simplified risk indicators, allowing to identify assets or asset typologies requiring a more detailed assessment, by means of diagnostic tests, monitoring, modelling and analysis. This also aims at defining homogeneous retrofit strategies to be implemented later on.

The objective of this organization is also to attract and convey forms of sponsorship to reduce costs and disseminate the culture of prevention and maintenance.

The screening of the architectural building stock hence includes (extending what required in the Annex A of [25]):

- identification of the asset, morphology, valuable elements, functions housed, etc.;
- sensitivity factors, dimensions, localization, soil and foundation system, accessibility and state of use;
- identification of building construction details;
- state of conservation, damage and/or deterioration mapping;
- presence of architectural barriers
- escape routes and fire safety;
- energy aspects, climate control, thermal bridges, heat generation systems.

The assessment of the aspects related with accessibility, safety at work and energy efficiency was further extended to the entire building stock of the University of Pavia, within a following project carried out by the EUCENTRE Foundation. This first assessment allowed identifying emergency situations requiring priority actions and, in parallel, defining a structural assessment program of the buildings, according to [25–27].

The rehabilitation of the heritage building stock and a rational use of resources and spaces would allow to extend the possibility of hosting functions and events, hence attracting forms of sponsorship. This could start a virtuous circle, further attracting funding for the conservation of the building stock itself, making the enhancement of the heritage buildings economically sustainable.

For a selected case study, San Felice Palace, which is in undeniable emergency conditions, more detailed analyses were carried out, with specific reference to the aspects of structural safety and accessibility.

#### 3.1. Structural and Seismic Safety

The structural performance of heritage buildings is assessed according to [25], which refers to the indications reported in the Italian building code [28] and corresponding commentary [29], but with a specific focus on cultural heritage buildings. The Ministry of Cultural and Tourist Heritage and Activities (MIBACT) [25] defines a multilevel process of knowledge, seismic safety assessment and design of possible risk mitigation interventions, specifically conceived for heritage buildings. The process is based on three levels of assessment, with increasing complexity and different applications, depending on the type of analysis and/or intervention to be carried out on the building.

The first level, called AL1, is aimed at providing a seismic safety assessment at territorial scale, for seismic prevention politics and is based on simplified methods, requiring a limited number of geometrical and mechanical parameters.

The Italian Building code NTC08 [28] considers for cultural heritage assets either strengthening interventions or local upgrades. MIBACT [25] hence introduces two additional levels of assessment: level AL2, for local repair interventions and level AL3, for strengthening interventions. The three levels of assessment will be discussed in more detail in the following subsections.

### 3.1.1. Simplified First Level Assessment (AL1)

The proposed approach for AL1 varies as a function of the typology of the considered historical-architectural asset. For the case of palaces and villas, it proposes some simplified mechanical models considering the deformability and strength of materials and structural elements; in case, instead, of churches and buildings with very large rooms, it proposes models based on the limit equilibrium analysis of the different building elements.

The simplified method proposed for palaces, which was applied in most cases in this work and in particular for the case study of San Felice Palace reported in this paper, assumes a box behaviour of the building, thanks to the good connection of walls at the corners and/or to the presence of steel tie rods and (infinitely) rigid diaphragms in their plane. Under this assumption, the model allows the evaluation of the seismic action leading to the considered limit state, provided that walls are failing in their plane. This seismic action is calculated based on the elastic response spectrum ordinate, which depends on building shear strength, obtained as the minimum of the shear strength calculated for each level and for each direction of analysis.

The shear strength at a given storey is evaluated considering the fraction of participating mass and the distribution of the floor seismic forces, determined by assuming a deformed shape, either triangular or with a damage concentration at the ground storey. After calculating the building shear strength and the corresponding spectral ordinate, the seismic safety index can be evaluated (Equation (1)) as the ratio of the return period of the seismic action leading to the considered limit state (life safety in this case),  $T_{LSLS}$ , and the corresponding reference return period,  $T_{R,LSLS} = 712$  years:

$$I_{S,LSLS} = \frac{T_{LSLS}}{T_{R,LSLS}}, \quad (1)$$

This seismic safety index would suggest the need of more refined evaluations on the seismic behaviour of the asset, in case the seismic action leading to a life safety limit state is lower than the expected seismic action at the site.

The acceleration factor (Equation (2)) is then defined as the ratio of the ground acceleration corresponding to the attainment of the (life safety) limit state,  $a_{g,LSLS} = 0.082$  g, and the design reference acceleration  $a_{g,LSLS}$ , corresponding to the return period of the limit state seismic action  $T_{R,LSLS}$ , for soil type A:

$$f_{a,LSLS} = \frac{a_{LSLS}}{a_{g,LSLS}}, \quad (2)$$

### 3.1.2. Second Level of Assessment (AL2)

Level AL2 envisages a seismic assessment based on models of limited portions of the building, analysed either with nonlinear finite element models or with limit equilibrium analysis of overturning and collapse mechanisms.

The most significant local mechanisms for a building can be identified based on the seismic behaviour of similar buildings damaged by a seismic event, by considering the possible presence of cracks in the buildings, the level of connection of masonry walls, the masonry layout, the presence of tie rods, the interaction with other elements of the building or of adjacent buildings.

The seismic action able to activate these mechanisms can be calculated in terms of the seismic coefficient  $\alpha_0$ , i.e., the horizontal load multiplier corresponding to the activation of the mechanism.  $\alpha_0$  is evaluated using the linear kinematic method, based on the identification of the portion of the building interested by the local mechanism of collapse. Each element is modelled as a rigid block, part of the kinematic chain, able to rotate and/or to slide. The forces acting on the system (i.e., self-weight of the blocks, vertical loads, a system of horizontal loads proportional to the vertical loads and possible external forces) are applied to these rigid blocks. The collapse multiplier is then obtained by the principle of virtual works, by equating the virtual work of external and internal forces.

### 3.1.3. Third Level of Assessment (AL3)

The assessment level AL3 considers the global seismic safety of the building and needs to be selected in case of interventions affecting the structural behaviour or in case of a strategic or socially relevant asset, for which a reliable safety assessment is required. The global assessment of the seismic response can be carried out either using global models, or using a decomposition of the structure into macroelements, provided that the seismic actions are correctly assigned to the different structural systems, as a function of stiffness and connections among the parts.

### 3.1.4. Considerations Obtained by Applying the AL1 Method to the University of Pavia Building Stock

The first level assessment (AL1) was applied to all the historical buildings of the University of Pavia, with few exceptions of buildings that had already undergone significant interventions. In particular, the methodologies for “palaces,” “towers” and “churches” (for the Aula Magna) were applied.

Table 1 summarises the results obtained for three buildings; i.e., the Botanical Garden Palace and San Felice Palace, used as university departments and classrooms, and the Spallanzani College. Values of the safety index,  $I_{s,LSSL}$ , and the acceleration factor,  $f_{a,LSSL}$ , for the two considered deformed shapes (linear and uniform), with reference to the life safety limit state are reported.

**Table 1.** Results of the AL1 (first-level) assessment for the considered buildings neglecting the effect of irregularities in height.

Deformed Shape	Botanical Garden Palace		San Felice Palace		Spallanzani College	
	Linear	Uniform	Linear	Uniform	Linear	Uniform
$T_{LSSL}$ [s]	540	345	695	435	390	670
$a_{LSSL}$ [g]	0.074	0.062	0.081	0.068	0.065	0.080
$I_{s,LSSL}$	0.76	0.48	0.98	0.61	0.55	0.94
$f_{a,LSSL}$	0.90	0.76	0.99	0.83	0.79	0.98

Following [25] at the AL1 level, the values of the indexes strongly depend on the knowledge level of the structure, concerning structural details, construction quality, materials and corresponding mechanical parameters. It can be noted that a different assumption on the deformed shape would result in a significant variation in the results in term of  $I_{s,LSSL}$ , with an increment of even 50% when assuming a soft storey mechanism at the ground level (uniform load pattern).

These preliminary results deriving from extremely simplified models allow highlighting buildings with macroscopic or probable deficiencies from the point of view of seismic safety. However, they cannot be directly used for the design of interventions, for which detailed analyses of the different structures are required.



### 3.2. Accessibility and Usability

Another issue concerning a proper conservation and valorisation of the heritage is represented by the safe and easy accessibility and usability of environments and buildings, considering also people with disabilities, elderly, children and people with special needs.

With the Italian law 13/1989 [30] and the subsequent requirements of the Ministerial Decree DM 236/1989 [31], the basic concept of “architectural barriers” is defined as the following three aspects:

- physical obstacle, source of discomfort for the mobility of anyone and in particular of those who, for whatever reason, have a reduced or impaired mobility capability in a permanent or temporary case;
- obstacle that limits or prevents the comfortable and safe use of parts, equipment or components;
- lack of measures and signs that allow the orientation and recognition of places and sources of danger for anyone and especially for blind, visually impaired, deaf and hard of hearing people.

It can be noted that the “architectural barriers” are not only related to physical obstacles for people with mobility impairments, but also to obstacles of perception for people with sensorial impairments, caused by the lack of information. In the same document, together with this characterization, the term “accessibility” is defined as “the possibility, even for people with reduced, or prevented, motor or sensory ability to reach the building and its environmental units, to enter it easily and to use spaces and equipment in conditions of adequate safety and autonomy” [31].

Unfortunately, the normative framework is quite far from real applications and situations: concerning the overcoming of architectural and sensorial barriers there is an important lack of wide-ranging policies, aiming at full and conscious individual emancipation and a social inclusion of people with disabilities.

Another key law is represented by the Ministerial Decree DM 127/2008 [32], characterised by a performance-based approach able to include the multiplicity and singularity of the cultural heritage, that cannot be confined into the definition of standardized solutions. It highlights how accessibility constitutes one of the bases of design and restoration. The 2008 guidelines, focusing on the new awareness introduced by the International Classification of Functioning, Disability and Health (ICF) model [33], emphasize the importance of including the different disabilities—with the associated issues—and the specific individual and environmental characteristics.

From an initial simple approach which looked only at the removal of architectural barriers with normative constraints, often in contrast with heritage conservation needs, the accessibility is now considered as a complex theme, which puts together the relationship between conservation and fruition of the heritage [32]. In this perspective, the instances of accessibility “have to be considered as normal design elements, as safety, structural stability, comfort, building and urban regulations, economic constraints, guidelines of restoration, reversibility, physical and chemical compatibility, expressive authenticity” [34]. For these reasons, a detailed knowledge of the historical building under investigation is fundamental, in order to understand all the features to be stressed and enhanced. The designer, with a critical approach for any specific case-study, has to consider accessibility and usability as factors for enhancing the asset.

Thanks to [33,34], the old idea of “handicap” as a physical impairment that makes a person “invalid”, crossing the concept of “mobility and sensorial disabilities” as a linear result of the disease, finally switches to the “bio-psychosocial” approach, which combines personal features with environmental contextual factors. This new approach underlines the concept of “activity”, highlighting the strict dependence on contextual factors in which the person lives: anyone, at any time of life, can be in health conditions that can become “disabling conditions” if contextualised in an unfavourable environment. Therefore, the “disability” is an evolving concept, due to the “interaction between people

with impairments and attitudinal and environmental barriers that prevent their full and effective participation in society based on an equality" [35].

According to this point of view, the role of the designers acquires relevance in applying the principles of inclusive design as a design tool that can improve the quality of built environment. In particular, the environment is functionally accessible and usable if it provides also information useful for self-orientation and recognition of the most significant elements, regardless of the sensorial or cognitive conditions of the users.

Before being able to intervene on the built heritage with architectural solutions improving accessibility, it is necessary to investigate and understand its state of the art. To do this, the use of assessment tools is required. Depending on the methodology adopted, the assessment tools of building performance can be classified into:

- multicriteria methods, characterized by a wide range of parameters from which a qualitative or quantitative evaluation is obtained [36];
- methods with synthetic indicators: analytical tools formed by a reduced number of parameters providing quantitative assessments [36].

In the literature, it is possible to find several tools to calculate sustainability levels and energy behaviour of buildings, but it is not so spread the assessment of accessibility and usability, due to the complexity of this issue in relation both to the numerous variables under consideration and to the high degree of subjectivity that it involves.

In the international context the first examples are in the United States and Great Britain, where they started to use detailed checklists listing the architectural elements that most influence the accessibility of buildings, consisting in closed questions (Accessibility Checklist, 2001) or in lists derived from regulatory provisions (Americans with Disabilities Act, 1995). Another example is the Prospelas project (2009) [37], in which the accessibility of historical monuments and archaeological sites of Thessaloniki (Greece) are investigated through the definition of six checklists.

Other checklists are flanked by more in-depth calculation methodologies, as for example the Analytic Hierarchy Process (AHP) [38], a multicriteria evaluation method that identifies the specific weight of the indicators through a comparison in pairs and the consequent determination of the hierarchies of influence. The University of Salford applied this methodology to the specific issue of accessibility identifying as accessibility criteria on the one hand physical characteristics (external environment, entrance, horizontal circulation, vertical circulation, services, signage, emergency) and on the other the management system (access information, staff attitude, management policies and practices, maintenance).

Furthermore, there are examples of "quantitative" analysis, reporting *true* if the numeric value detached corresponds to the normative or *false* if not, as for the census of the architectural barriers developed by the National University Conference of Delegates for Disability, and examples of "qualitative" analysis entrusted to the direct and subjective experience of disable users and visitors, according to three levels: *accessible* (green), *partially accessible* (yellow) and *not accessible* (red), as for the report of the University of Naples or several websites and blogs of hotels and tourist facilities.

From this brief methodological framework, it is clear the need to work on the development of objective and multidisciplinary assessments, with the aim of:

- reducing the subjective nature of accessibility assessments;
- objectively breakdown the building into elements easily investigable, also to facilitate the identification of the most critical points;
- summarizing the information into an overall assessment;
- ensuring the flexibility and exportability of the tool;
- letting an objective comparison of the results of different case-studies.

The prototype assessment tool "A.tool" [39] has been developed to try to achieve these purposes. It allows to evaluate the accessibility levels of historic buildings on the basis of a specific algorithm, producing objective investigations, with comparable results. It breaks down the building under investigation into *areas* and *subareas*, each of which is defined

by a series of objectively measurable *indicators* and *parameters*. The different areas are divided into invariant (entrances, horizontal connections, vertical connections, rest rooms, common spaces) and functional spaces (teaching rooms, libraries, laboratories, offices), which are flexible according to the specific function of the building. “A.tool” computes the accessibility level of each area and of the whole building, separating the assessment of mobility and visual impairments and objectively mapping all the critical issues of buildings, supporting the planning of design interventions.

San Felice Palace was the first case-study to which “A.tool” was applied (2013). Thanks to this research it was possible to understand the building’s state of the art, its strengths and weaknesses. The objective and punctual assessment resulting from “A.tool” is the base of the integrated strategies and the architectural solutions proposed in this paper to improve the accessibility and the quality of the building. (Figure 3).



**Figure 3.** Ground floor of San Felice Palace with the results of the accessibility assessment of entrances (E) and the horizontal connections (H) through the prototype assessment tool A.tool, which provides results into five different levels of accessibility (from A to E) for mobility impairments (left paddles) and visual impairments (right paddles).

San Felice Palace was also the case-study of the winter school in accessibility with ThyssenKrupp Encasa [40], an intensive international didactic experience focused on the development of architectural solutions to improve accessibility and usability. The students worked on the overcoming of architectural barriers, the orientation system inside and outside the building and the redesign of the four courtyards to enhance the overall aspect of the palace.

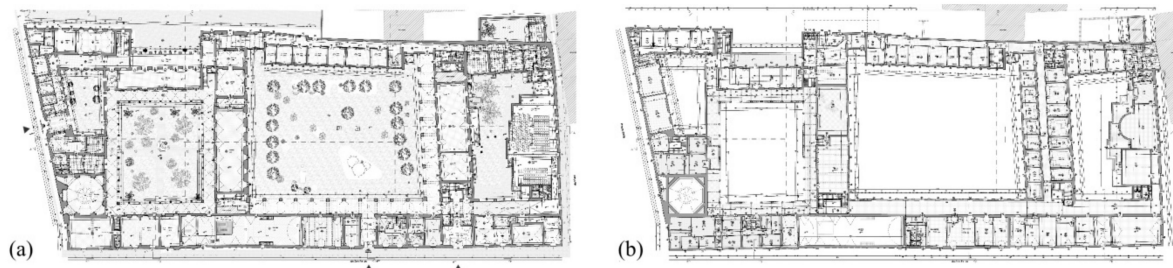
#### 4. Example of Application of the Integrated Procedure

The proposed integrated procedure was applied to one of the heritage buildings of the University of Pavia, selected as a case study. The selected building is the former monastery of Saint Felice, which is today the headquarter of the Department of Economics and Management, the Institute of Psychology and the Section of Philosophy of the Department of Humanities of the University of Pavia. The current building is the result of different construction phases, such as interventions of restoration, renovation and new construction, which significantly modified its aspect [41]. The first documentary sources on the complex date back to the eighth century. In 1996–1997, three archaeological excavation campaigns were carried out and allowed the identification of the different construction phases of



the complex, with a development along the length of the building [42,43]. The monastic complex was renovated between the middle of the fifteenth century and the seventeenth century and it was then converted into an orphanage in 1785. After being acquired by the University of Pavia around 1980, the entire eastern wing was subjected to demolition and reconstruction works, to realise classrooms and the Aula Magna of the Faculty of Economics.

The complex of the former monastery of San Felice has a nearly rectangular plan, with dimensions of approximately  $150 \times 40$  m (Figure 4).



**Figure 4.** Plan views of the ground floor (a) and first floor (b) of San Felice Palace.

It is realised with clay brick masonry, with the exception of the eastern wing, in which the Aula magna and some classrooms were realised in the 80's with a reinforced concrete frame. The roof is characterised by an irregular plano-altimetric configuration, with a wooden truss structure and tile covering. The building has two storeys above ground, with the exception of the north-western portion, in which an additional level is present.

The structural aggregate is organised around four internal courtyards: two minor courtyards at the eastern and western ends, a central courtyard and a cloister originally built in the fifteenth century, to which a level was later added by Leopoldo Pollack. This cloister and the former church of San Felice have a particular artistic and architectural value. Unfortunately, the columns of the cloister, made of Angera stone, present a significant level of deterioration.

#### 4.1. Structural Assessment

The results of the AL1 procedure for San Felice Palace were already presented in a previous section. For the case study building, the assessment levels AL2 and AL3 of [25] were carried out as well and the assumptions and results are discussed in the following subsections.

Before being able to carry out analyses at the higher assessment levels, the knowledge on the building was increased by means of detailed surveys of the roof structure, evaluation of the axial force in the tie rods by means of dynamic tests and non-destructive tests on the columns of the cloister. The tests on the columns will be briefly presented in the following subsection.

##### 4.1.1. In Situ Non-Destructive Tests on the San Felice Cloister

Despite the generally good conservation conditions of the San Felice Palace, in some parts a more or less severe level of degradation can be observed, due essentially to the building's age and the action of atmospheric agents. Particularly critical are the conditions of the columns of the fifteenth-century cloister (Figure 5), as they present both significant degradation due to the gypsum neogenesis inside the Angera stone, and significant cracks in the bulbs (Figure 6). This problem was faced in the past by applying steel hoops, most of which are currently ineffective, because of the deterioration of the joint nail, which lost its capacity of stress transfer, and hence its confining action.



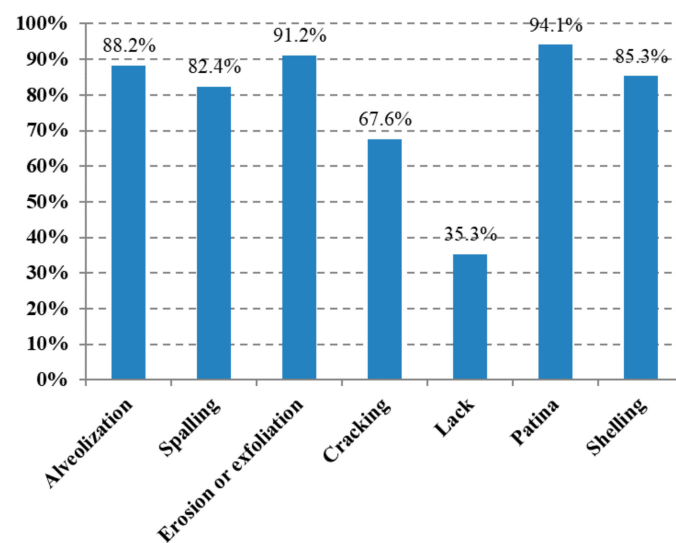
**Figure 5.** A view of the fifteenth-century cloister of San Felice Palace.



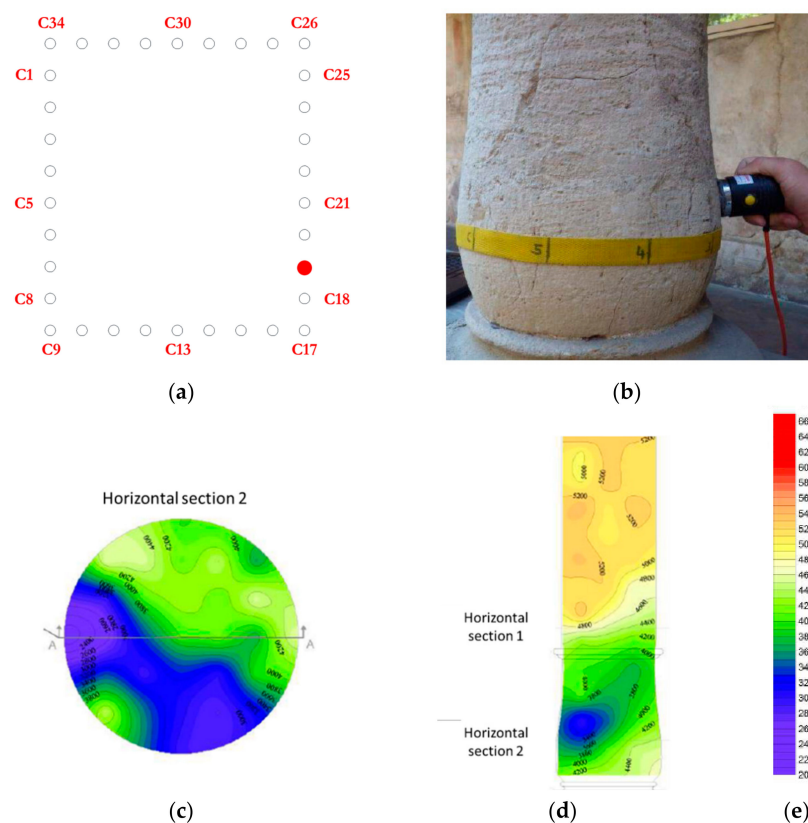
**Figure 6.** Degradation in the cloister's columns due to gypsum neogenesis with the presence of cracks in the columns' bulbs.

Angera stone, used diffusely in historical buildings in Lombardy, is indeed particularly susceptible to degradation phenomena and, in particular, to gypsum neogenesis, not only of the block surface, but also deeply inside the columns. This can create safety issues of this structural portion of the complex, due to the reduced columns' section which can affect their vertical load-bearing capacity. For this reason, within the SICURA project, a detailed survey of all columns of the cloister was carried out, observing the types of damage or deterioration summarised in Figure 7.

To have a better insight on the actual conditions of the colonnade, some non-destructive in situ tests were carried out, consisting in dynamic vibration tests on tie rods, to evaluate the force acting in the steel ties, and ultrasonic tomography tests on horizontal and vertical sections of the columns. The aim of this type of tests is to evaluate the elastic characteristic of the columns and, more specifically, to identify possible existing cracks and, when possible, to spot the presence of weak areas inside the columns. This allows evaluating the level of degradation and the effective resisting section of each column. Figure 8 reports the results obtained for one of the columns, selected as an example. The colour scale indicates the velocity of P-waves detected through the test. The presence of a significant crack is evident both from the picture (Figure 8b) and from the results of the tomography test on the horizontal and vertical section (Figure 8c,d, respectively), where a slowing effect of the P-waves is clearly visible (blue areas in the plot).



**Figure 7.** Types of damage or deterioration observed in the columns of the fifteenth-century cloister of San Felice Palace, with indication of their frequency of occurrence (in percent over the total number of columns).



**Figure 8.** Results of the ultrasonic tomography tests on one of the columns of the cloister: location of the column within the colonnade plan (a), view of the column with evidence of cracking (b), results of the tests in terms of P-wave velocity for a horizontal (c) and a vertical (d) section and corresponding colour scale (e) in m/s. (Photo b taken by the authors).

Similar results were obtained for several other columns in the colonnade and this suggested the need of an intervention on this specific area of the complex.

The comparative analysis of the degradation levels of the stone elements allowed distinguishing among seriously deteriorated elements, with passing cracks evident from



ultrasonic tomography tests, elements with surficial cracks or even significant exfoliations but limited to the cortical block layer, and elements in discrete conservation conditions. For each degradation level, an intervention was programmed. In case of severely damaged elements, since the resisting section of the column is reduced to approximately one third by passing cracks, it is first necessary to restore the structural functionality. This can be achieved either by restoring the section adhesion, whenever possible, or by replacing the column bulb, using concrete agglomerates of the same colour or stone materials compatible with the Angera stone, in terms of colour and porosity but, if possible, with a higher strength, to be able to carry vertical and seismic loads.

For elements with limited and surficial cracks, for which structural stability is not an issue, the intervention will consist in in-situ strengthening without substitutions, with a sequence of pre-consolidation, desalination, strengthening and protection steps.

For discrete conditions elements, the intervention will aim at limiting the degradation phenomena due to sulphation of the stone surface by means of protective treatments.

These interventions have been programmed and will be hopefully realised very soon. Similar interventions were recently carried out in the courtyards of the Borromeo and the Ghislieri Colleges, in which the Angera stone was diffusely used both as a decorative element in friezes and ledges, and as material for structural elements, in particular for column bases.

#### 4.1.2. Assessment of Local Mechanisms (AL2) for San Felice Palace

For the assessment of the local failure mechanisms, required by MIBACT (2011) at AL2, the following mechanisms were considered:

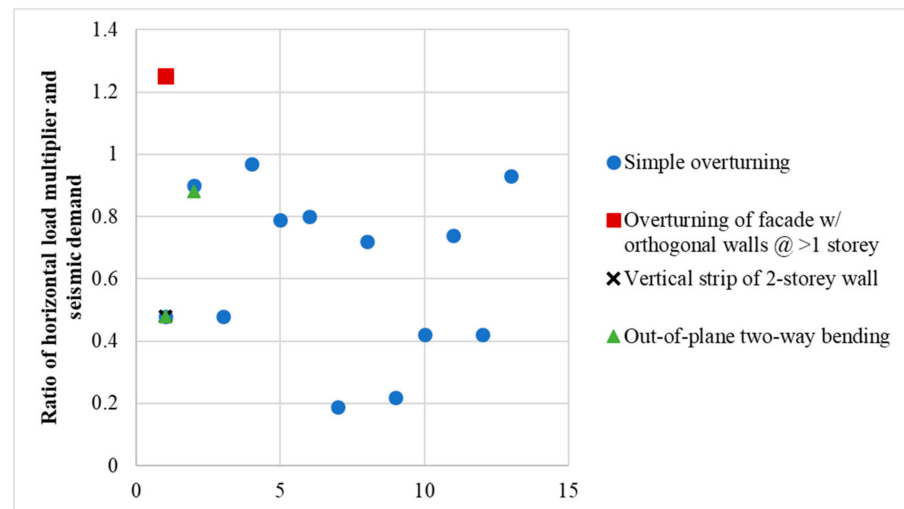
- simple overturning of walls with one or more storeys;
- overturning of the facade involving portions of the orthogonal walls at more than one storey (Figure 9a);
- vertical strip mechanism of a two-storey wall;
- out-of-plane two-way bending mechanism (Figure 9b);
- overturning of wall corners.



**Figure 9.** Identification of the possible overturning mechanism of the façade involving portions of the orthogonal walls at more than one storey (a). Definition of the constraints and possible activation areas of the out-of-plane two-way bending mechanisms (b). (Photos taken by the authors).

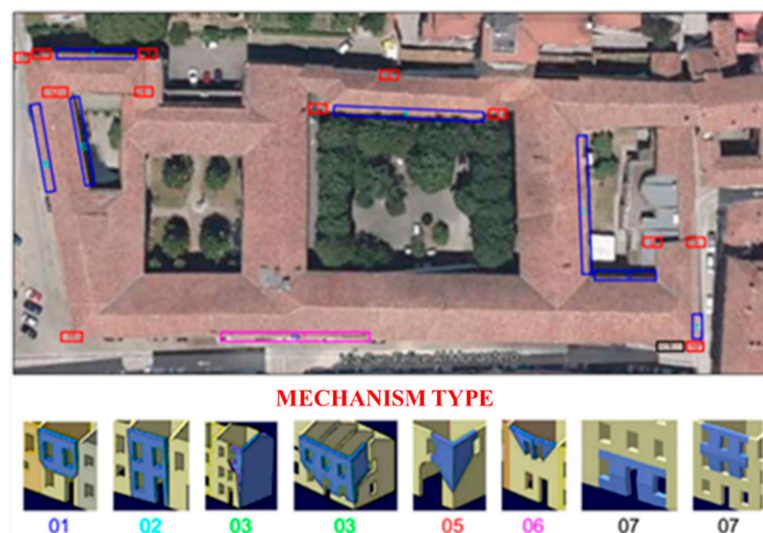
For each possible out-of-plane mechanism, the horizontal load multiplier  $\alpha_0$  was determined by linear kinematic analysis, applying the principle of virtual works and comparing it with the expected horizontal acceleration for a return period of 712 years, corresponding to the life safety limit state. A summary of the results obtained, in terms of the ratio between the horizontal load multiplier and the seismic demand at the base of the mechanism, is reported in Figure 10, for the considered mechanisms. It can be noted that the San Felice complex resulted to be vulnerable to the activation of simple overturning mechanisms (involving one and more than one storey), overturning of wall corners and out-

of-plane two-way bending mechanism, with average values of the ratio around 0.66 and, in few cases, values around 0.2. The results corresponding to the overturning mechanism of wall corners were not calculated, as the complex was deemed to be highly susceptible to this mechanism and, hence, a strengthening intervention was programmed, independently from the values of  $\alpha_0$ .



**Figure 10.** Results of the considered out-of-plane mechanisms for the San Felice Palace, in terms of the ratio between the horizontal load multiplier and the seismic demand at the base of each mechanism.

Figure 11 shows the location in plan of the structural portions susceptible to the most critical out-of-plane failure mechanisms.



**Figure 11.** Location in plan and identification of the most critical out-of-plane mechanisms for the San Felice Palace.

To contrast this important source of seismic vulnerability for the building, some possible interventions were envisaged. Regarding the roof, since the cause of activation of the mechanisms of overturning of wall corners, two-way bending and simple overturning (of the attic portion) is essentially the limited degree of connection between roof and masonry, strengthening interventions should aim at improving this connection, by inserting steel tie beams at the gutter level.

Considering mechanisms involving masonry walls, the main reasons for the activation of simple overturning and vertical strip mechanisms are related with the scarce degree of connection between floors and masonry. Hence, possible retrofit solutions could be:

- for wood floors: insertion of steel elements, well connected to the masonry, at the intrados/extrados, depending on the local characteristics of the structure, or the insertion of anchored steel ties between beams and masonry;
- for steel diaphragms with hollow clay blocks: insertion of steel tie beams at the floor level, with passing through bars connecting them to the masonry;
- for masonry vaults: insertion of tie rods.

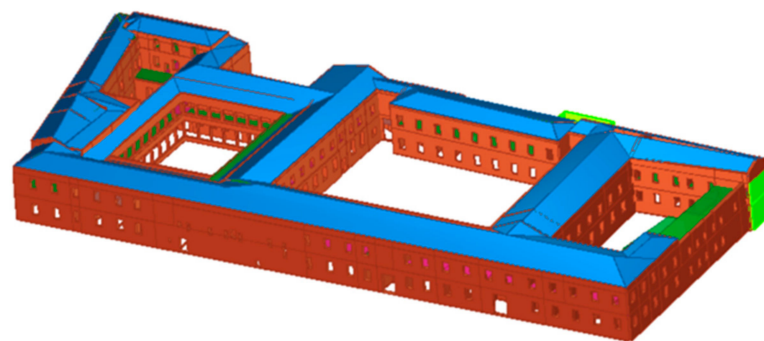
#### 4.1.3. Assessment of the Global Response (AL3) for San Felice Palace

The assessment level AL3 of [25] assumes that the building is able to develop a global response, governed by the in-plane behaviour of the walls. The building was modelled using an equivalent frame approach, with nonlinear macroelements [44] representative of the cyclic behaviour of masonry walls and spandrels, implemented in the program TREMURI [45]. For the details on the modelling assumptions, the reader is referred to the indicated publications and to the many applications of the program for similar problems [46,47].

The mechanical properties assigned to the structural elements correspond to average values from literature characterization tests on solid brick masonry [48,49], since it was not possible to carry out specific tests to derive material properties of the San Felice complex. The values of the mechanical parameters adopted in the model are reported in Table 2, where  $E$  is the Young's modulus in compression,  $G$  is the shear modulus,  $\rho$  is the masonry density,  $f_m$  is the masonry compressive strength,  $c$  is the cohesion in the macroscopic model of shear strength. Figure 12 shows a 3D view of the numerical model of the complex.

**Table 2.** Mechanical parameters of the macroelements.

E [MPa]	G [MPa]	$\rho$ [kN/m <sup>3</sup> ]	$f_m$ [MPa]	$c$ [MPa]	$\mu$ [-]
3000	500	18	2.8	0.14	0.15



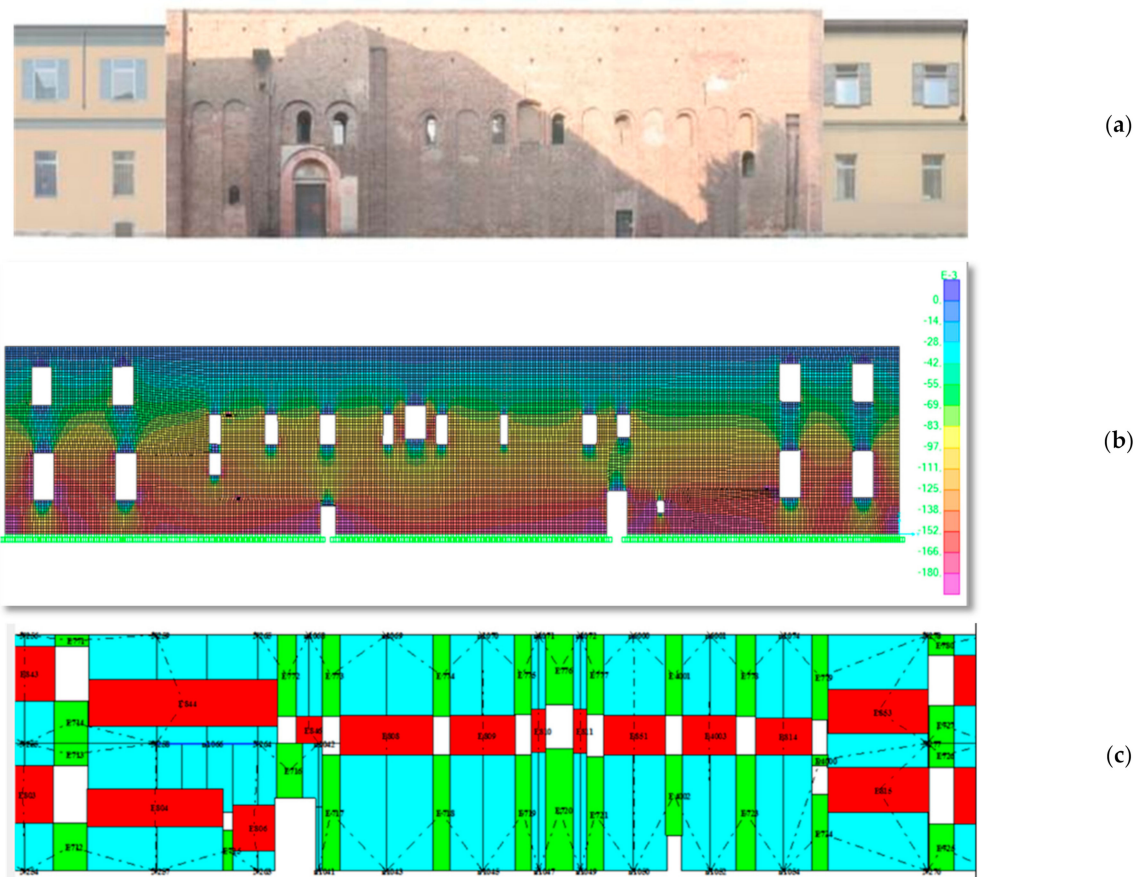
**Figure 12.** View of the 3D numerical model of San Felice Palace.

Different types of diaphragms are present in the building and they were modelled considering their typology, geometrical characteristics and mechanical properties:

- timber diaphragms with joists and single plank layer;
- steel diaphragms with hollow clay blocks or brick vaults;
- brick masonry vaults;
- rigid diaphragms in the eastern wing, realised as a reinforced concrete frame.

All diaphragms were modelled as four-node orthotropic membranes, with two displacement degrees of freedom at each node. In case of vaults, a diaphragm with equivalent stiffness was defined, according to [50].

The identification of the equivalent frame discretization of the structure requires an assumption on the effective height of the masonry piers, which is based on conventional criteria discussed in the literature (e.g., [51,52]) and on the observation of post-earthquake damage on similar structures (e.g., [53,54]). In case of walls with regular openings, the identification of the equivalent frame scheme is quite simple, whereas it becomes critical in case of irregularity in the openings of a wall, as in case of the south façade of the former church of the complex (Figure 13a).



**Figure 13.** View of the southern façade of the former San Felice church (a); vertical compression stress  $\sigma_{11}$  for seismic action in the  $X+$  direction (b); equivalent frame mesh adopted for the analyses (c).

The automatic discretization provided by the algorithm embedded in the professional version of the computer program (3Muri) was hence modified in some cases, to account for specific boundary conditions, openings arrangement and wall geometry. To help identifying the most correct equivalent frame discretization of such a complex structure, a linear analysis was carried out with a finite element program (SAP2000), to qualitatively define the stress distribution within each wall (Figure 13b). Indeed, the distribution of stress in the different directions allowed delimitating the masonry piers and spandrels and then the geometry of the rigid nodes. The selected mesh is shown in Figure 13c.

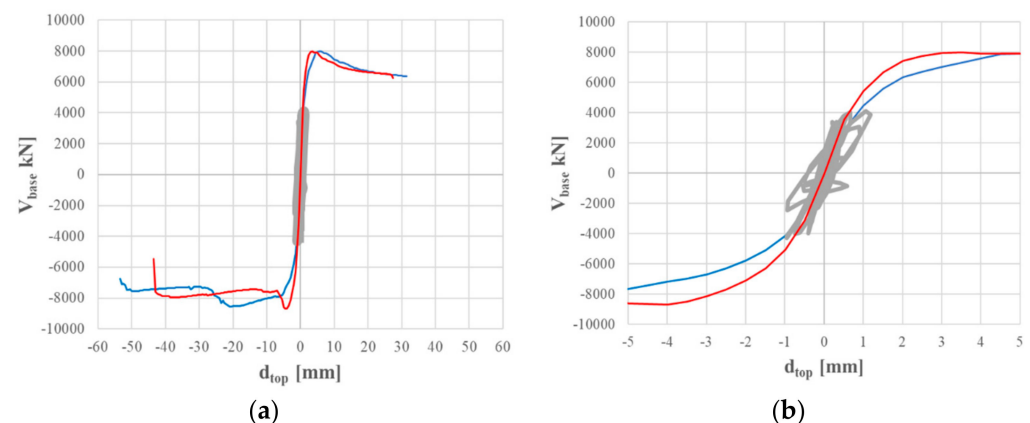
The presence of flexible diaphragms and the high degree of irregularity in the structural geometry make nonlinear static (pushover) analysis not suitable to assess the global seismic response of the entire 3D building model. Issues related to the dependency on the selected control degree of freedom and limited possibility of force redistribution among different walls prevent the application of this nonlinear analysis method to the whole model. Alternatives are the use of separate pushover analyses of single walls (in-plane), allowed by the Italian building code for masonry structures with flexible diaphragms, or a combined use of “local” 2D pushover analyses, to assess the lateral wall capacity with



the identification of displacement limit states, and “global” 3D time-history analysis, to compute the displacement demand for each wall, accounting for the limited coupling effect provided by deformable diaphragms. The latter strategy was selected for this case study.

To run nonlinear dynamic analyses, seismic input was defined by selecting real records, spectrum-compatible with a displacement response spectrum, from the SIMBAD database [55].

The numerical analysis results on the model’s global response show a very limited seismic vulnerability, as reported in Figure 14, where the in-plane displacement demand computed for the southern façade of the building via time-history analysis for one of the selected records is compared to the capacity curves obtained from pushover analysis (in positive and negative directions). This implies that for the seismic hazard of Pavia the urgent interventions on the damaged cloister accompanied by a set of diffused low-impact interventions (e.g., steel ties to improve wall-to-diaphragm connections and contrast vault thrusts) would guarantee a sufficient seismic performance of the building.



**Figure 14.** Comparison of capacity curves obtained from pushover analyses with the two considered force distributions (mass proportional (red) and inverse triangular (blue) force distribution) and hysteretic curve provided by time-history analyses, for the southern façade (a) and a zoom in the low displacement range (b).

#### 4.2. Accessibility

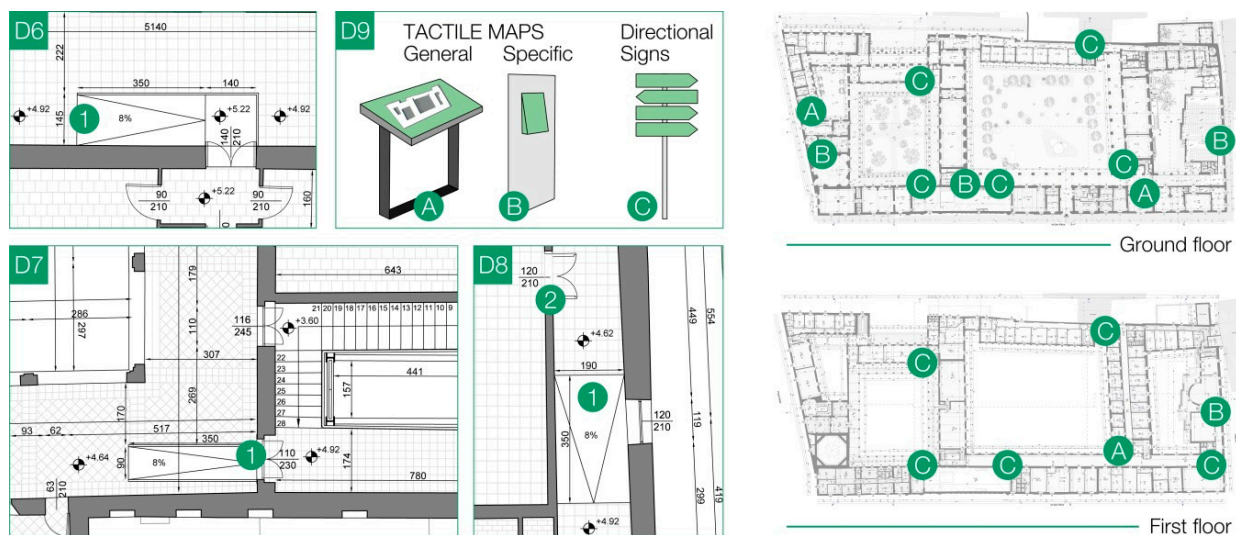
Thanks to the in-depth studies developed during these years on the accessibility of San Felice Palace, the main critical issues of the building are identified:

- the mobility along the outdoor spaces adjacent to the building entrances is difficult due to the presence of a cobbled pavement;
- the mobility along the horizontal connective—both at the ground floor and at the first floor—is conditioned by the presence of differences in height along its development;
- the entrances have differences in height and the ramp at the pedestrian entrance to via San Felice is not properly designed;
- the access to the first floor is conditioned by the presence of only one elevator, which is not sufficient, considering the dimensions and the discontinuity between the parts of the building;
- the access to several rooms and spaces is problematic due to the presence of steps;
- the usability of the whole building is not inclusive, due to the absence of a consistent and uniform system of signs, with multisensory elements.

For these critical issues, design interventions are required to improve the situation and guarantee inclusivity, always respecting the principles of conservation and enhancement of the architectural heritage. Details of the designed interventions (indicated with progressive numbering from D1 to D9) are discussed in the following, with reference to Figures 15 and 16.



**Figure 15.** Details (D1, D2, D3, D4, D5) of the design solutions for the ground floor of San Felice Palace: 1. Inclined steel surface with anti-slip treatment; 2. informative-tactile map; 3. paving in stone slabs; 4. stone seats with armrests and space for wheelchairs; 5. new ramp; 6. new metal staircase with double height continuous handrail; 7. new elevator; 8. pantograph platform embedded in the pavement; 9. new accessible toilets.



**Figure 16.** Details (D6, D7, D8, D9) of the design solutions for the first floor of San Felice Palace and for the signage system: 1. ramp with double handrail for overcoming limited gradients, at different thresholds and along the corridor; 2. restoration of the access door; A. general tactile map; B. specific tactile map at the most important room; C. directional indications.

#### 4.2.1. Overcoming the Differences in Height at the Entrance to Piazza Botta (D1 and D4)

The entrance to Piazza Botta has a difference in height of 5 cm. The installation of an inclined plane of steel fitting with a nonslip surface treatment is proposed. The cobblestones at the entrance are removed for the installation of stone slabs, coplanar to the pre-existing ones. The project also includes the installation of an informative-tactile map depicting the ground floor of the whole building, with signs in relief and in Braille. In addition, the cloister is characterized by a gravel pavement, not accessible to people with motor disabilities. The entire cloister will be repaved in stone slabs, with also new seats in correspondence with the pre-existing flower beds, equipped with backrest. The empty space between the benches is necessary to allow the approach of people with motor disabilities, using a wheelchair. The redesign of the cloister makes it possible to solve the difference in height of 30 cm with the fifteenth-century cloister: a connecting ramp along one of the two flower beds (slope 4%) is proposed. This ramp, in stone, has glass parapets

to allow full integration in the historical context, and a continuous double-height handrail (90 cm and at 75 cm).

#### 4.2.2. Overcoming the Difference in Height between the Fifteenth-Century Cloister and the Main One (D2)

Currently, the connection between the two cloisters is characterized by the presence of one step (about 20 cm) between the main cloister and the vertical connection and two steps (about 40 cm) between the vertical connection and the XV Century cloister. The project proposes a new stone connecting ramp, with glass parapets and double handrails. The pavement adjacent to the ramp is designed in stone slabs, different from the historical pavements, with an accentuated chromatic detachment from the ramp to facilitate its perception also to people with visual impairments.

#### 4.2.3. Overcoming the Difference in Height between the Ground Floor and the First Floor of the Building (D3)

The existing elevator, located in the northeast part of the main cloister, is not sufficient to distribute the first floor of the building uniformly, also due to the presence of differences in height along the horizontal connectors of the first floor. It is proposed to set up an elevator at the staircase located in the northeast part of the fifteenth-century cloister, which is redesigned in metal with a continuous double-height handrail (90 cm and 75 cm).

#### 4.2.4. Overcoming the Differences in Height at the Pedestrian Entrance of Via San Felice (D4)

The entrance to Via San Felice has a height difference of 7 cm with the outside, which is connected with a step, and a height difference of about 30 cm in the internal atrium, for which a ramp has been installed, whose position however does not allow a comfortable and safe use. To solve the difference in height at the threshold, the project proposes the installation of an inclined surface of steel connection with non-slip surface. For the difference in height in the internal atrium, however, the creation of a ramp of fitting would conflict with the entrance door or it would be excessively impacting. For this reason, the use of a pantograph platform is suggested, which disappears into the existing flooring. An informative-tactile map depicting the ground floor of the whole building is designed, with indications in relief and in Braille, to help people with visual impairments.

#### 4.2.5. Overcoming the Difference in Height along the Horizontal Connective (D5)

A connecting ramp for overcoming two steps (35 cm) along the horizontal connective is proposed. The choice is due to the need of guaranteeing level access to the toilet, to allow its use by people with motor disabilities.

#### 4.2.6. Repeatable Solution for Overcoming Differences in Height between 10 and 35 cm at First Floor (D6 and D7)

For the differences in height at the threshold between the horizontal connective and the local, in case it is necessary to preserve the existing, the project proposes the installation of a metal connection ramp, with anti-slip surface, double handrail (90 cm and 75 cm) and 10 cm-high protection kerb. The ramp is placed on the existing flooring, leaning on the historic surface, in order to be easily removable.

#### 4.2.7. Overcoming the Difference in Height along the Horizontal Connective at First Floor (D8)

The arrangement of a connecting ramp is considered, to overcome two steps (30 cm) along the connective horizontal on the first floor. The choice is due to the desire to improve accessibility for people with disabilities to two high-capacity classrooms. The ramp is designed with a double-height handrail, with material and chromatic differentiation with respect to the present flooring, with the aim of facilitating its identification by people with visual impairments.

#### 4.2.8. Signage (D9)

As emerged from the analysis, the signage system of San Felice Palace presents widespread issues. On the one hand, there are no multisensory elements that can help in autonomous orientation people with visual impairments; on the other hand, the directional and information indications are inconsistent with each other and they present criticalities of localization, morphology, colour and size. It is therefore necessary to design a uniform, consistent and multisensory sign system (with embossed and braille indications, QR codes and light and sound devices that can provide different sensory channels, also essential in terms of safety). Three different levels of information are proposed: (A) the general tactile map provided at the entrances and at the first floor at the main staircase, (B) the tactile map specification at the classrooms of greater historical-architectural value, including the reading room (in the former church) and the octagonal hall, (C) the directional indications at the intersections of the major flows of uses (Figure 16).

#### 4.2.9. New Inclusive Solutions for the Different Courtyards

The building is characterized by four courtyards that can be used to improve not only the accessibility but also the qualitative image of the whole building and valorise the heritage. Rethinking the use of the courtyards taking into consideration the principle of the inclusive design, would allow to create new inclusive spaces for everyone to study, to rest and to enjoy the environment.

In summary, the solutions identified to improve accessibility, also allow for an improved usability both in the interest of the specific functions housed in the building and for the enhancement of its historical-architectural value.

### 5. Conclusions and Ongoing Actions

An interdisciplinary survey of the historical-architectural heritage of the University of Pavia has been extensively launched, thanks to the need of a preliminary seismic vulnerability assessment and it has been carried out with the methods and tools described in this work. As expected, it revealed deficiencies and issues related with the different aspects considered.

In general, the comprehensive survey allowed to catalogue together structural and nonstructural damage, inadequacy with respect to some regulatory safety requirements for the specific use, deficiencies related to accessibility and orientation, inefficiency of technological systems, need for urgent interventions on one or more of these aspects.

Such a systematic assessment highlighted structural deficiencies in various buildings, emphasizing in particular the widespread need for maintenance interventions on roofs, which should be considered as an opportunity to improve connections between roofs and masonry walls, to prevent the onset of local out-of-plane collapse mechanisms triggered by the seismic action. The application of the simplified seismic assessment procedure to very complex irregular buildings showed some limitations as an effective screening of seismic vulnerability and it should be at least complemented with simple analysis tools for local failure modes (e.g., using abaci for typical out-of-plane mechanisms).

The collection of information was further extended within a specific project in collaboration with the EUCENTRE Foundation, which carried out a complete inventory. In some cases, it was also recognized that even geometrical survey information was not corresponding to the current arrangement of the buildings and a new survey using modern 3D scanning techniques was performed, with the final aim of obtaining building information models (BIM), also useful for managing and planning maintenance interventions.

The integrated approach presented in this study could be useful for defining the objectives of real estate asset management and allocating more effectively the budget for interventions, as well as for looking for different sources of funding, for example through the patronage of banking foundations. An example of application of the interventions delineated within this approach is the structural retrofit plan for San Felice Palace, currently under examination by the superintendence for architectural heritage. The plan has greatly



benefited from the investigations carried out on the building and is based on design solutions derived from what emerged in the analyses.

The seismic safety assessment of San Felice Palace indeed showed that the vulnerability of the structure emerges mainly in the potential activation of local failure modes, associated with out-of-plane overturning of walls or portions of walls, which could be limited by interventions aiming at improving the wall-to-diaphragm connections. Furthermore, the global response of the San Felice complex was modelled according to an equivalent frame approach with nonlinear macro elements, using the TREMURI software. Despite the considerable size and complexity of the building, this solution was deemed appropriate, as it allows to describe the overall dynamic behaviour of the structure and to grasp the main damage mechanisms. In this case, due to the structural irregularity and the presence of deformable diaphragms, it was decided to combine pushover analyses of single walls for defining capacity and nonlinear time-history analyses to evaluate displacement demand.

Another serious and widespread issue, not only in San Felice Palace, is the need to improve accessibility and orientation. On this aspect as well, the university is launching some corrective actions (e.g., a wayfinding project has been activated). Acting on accessibility and orientation, as demonstrated for San Felice Palace, can also become an opportunity to partially rethink the use of the spaces, improve the welcoming of the building, enhance its architecture and history, making mixed uses possible, for example with the organization of events opening up to new relationships with the city (museums, libraries, interior spaces, etc.). This research outlines approaches, analysis and assessments that focus on objective methods that can be used to investigate the accessibility levels of the historical environment in order to design inclusive design solutions. Clearly, a balance between conservation/enhancement/use is fundamental in the interventions on buildings with a high historical and architectural value.

In general, in addition to the specific innovations introduced in the assessment of the deficiencies related to accessibility and seismic/structural safety assessment, the new interdisciplinary methodology applied to the heritage buildings of the University of Pavia represents a step forward towards the development of integrated strategies for the conservation and enhancement of historic buildings, efficient and suitable for use. This study is also very useful for setting up prioritization schemes, to plan the pluriannual allocation of financial resources for cultural heritage conservation.

**Author Contributions:** This paper shows integrated strategies for the preservation and the enhancement of the built heritage, which are developed by two different working teams: (1) A.P., M.R. and I.E.S. for “Structural and seismic safety”; (2) V.G. and A.G. for “Accessibility and usability”. Concerning the issue “Structural and seismic safety”: methodology, A.P., M.R., I.E.S.; software, A.P.; validation, M.R., I.E.S.; formal analysis, A.P.; investigation, M.R., I.E.S.; resources, I.E.S.; data curation, I.E.S.; writing-original draft preparation, M.R. Concerning the issue “Accessibility and usability”: methodology, V.G., A.G.; project, V.G.; supervisor, A.G.; formal analysis, V.G.; investigation, V.G.; resources, A.G.; writing-original draft preparation, V.G. About the whole paper: conceptualization, A.P., M.R.; introduction, M.R., A.G.; writing-review and editing, M.R., I.E.S.; visualization, I.E.S.; supervision, A.P., A.G.; project administration, A.P.; funding acquisition, A.P., A.G. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was partially developed within the SICURA project, funded by the CARIPLO Foundation, through the programme “Promote good practices of prevention and conservation of historical and architectural heritage 2013”.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author.

**Acknowledgments:** Previous researches on San Felice Palace, coordinated by A. Greco and D. Besana, benefited from the involvement of students of the Master's Degree in Building Engineering and Architecture (courses of Architectural Drawing 2 and Survey 2). A winter school, organised in 2012 thanks to the support of ThyssenKrupp, in collaboration with the University of Cagliari, the Polytechnic of Turin and the Adrianea Academy, focused on the case study of San Felice Palace and provided interesting contributions for the improvement of accessibility. The structural assessment of San Felice Palace also benefitted from a detailed survey of the roof structure coordinated by M. Morandotti.

**Conflicts of Interest:** The authors declare no conflict of interest.

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