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REGENERATION OF A FORMER PRISON IN MELIPILLA, CHILE: USE OF DIGITAL TECHNOLOGY IN A HERITAGE RESTORATION PROJECT

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Abstract

Technology and automation in the field of cultural heritage provide an opportunity for the restoration of historical buildings that would otherwise remain abandoned and overlooked amid the current development of cities in Latin America. The present paper proposes the restoration and regeneration project to transform an abandoned former prison in the city of Melipilla, Chile, into a public library, upgrading and opening its spaces to the public and making contemporary use of this crumbling landmark that has a high potential of social renovation. The case study is the repurposing of a building of considerable cultural interest, neglected in an historical central urban tissue, by creating a new function and demonstrating the feasibility of upgrading an older structure to comply with current parameters of indoor environmental quality (IEQ) (i.e. light intensity and thermal comfort) through the appropriate use of passive energy controlled by means of a digital twin approach and automation of adaptive measures.

Introduction: Past, Present, Future

Architecture, particularly when a historical value is concerned, involves an act of mediation between past, present and future. It occurs through the insertion of something new into the established context, or through the transformation of an existing structure, destinating its space to new usages or modifying those for which it has hitherto served.

On this subject, Friedman (1992) proposes that the past is always practised in the present, as subjects structure the past through the practice of their identity (Friedman, 1992, p. 837). Past interventions of this type on buildings or cities have thrown both heritage urban spaces and existing architectural manifestations into tension. The magnitude and complexity of this tension is intimately bound up with the reputation and significance of the properties or the neighbourhoods in which they are located. When new built artefacts are carefully conceived to ensure their assimilation into the context for which they are destined, their impact is far lower. This is not only because they comply with interests regarding the existing urban space, but also because the latter is enriched by the new addition. By contrast, when the new realization (in the present) overlooks its context (from the past), ignoring the attributes of the place, there is a distortion of the urban components involved and, in turn, devalues the area.

In response to the devastating effect of climate change and the systemic alteration of the environment globally, there has been growing endorsement of the principles of sustainability, recycling and resource reuse. Numerous recent architectural endeavours have fallen into this category, focusing on the recycling and restoration (in the present) of abandoned or underutilised properties (from the past), reducing costs and collaborating, in passing, with environmental recovery and carbon footprint reduction.

It is in this context that proposed project to regenerate the former prison in Melipilla is addressed. The city is located in the Metropolitan Region of central Chile and the project is highly representative of some of the notions mentioned above, as it involves the restoration and repurposing of a disused building currently in an advanced state of deterioration, and whose indisputable heritage value in the present echoes the city's past, its own dark history, and its associated memory. The renovation of this historical building has been made possible by the opportunity to assign it a new cultural function. Furthermore, the use of digital design tools has enabled the evaluation and specification of various project alternatives, simulating suitable environmental conditions for its proposed uses and empowering the implementation of minimum-impact interventions with the help of existing automation technologies.

Heritage conservation in Chile

Heritage conservation presents the opportunity to repurpose and transform spaces to embrace new histories, thereby updating the function of old buildings and boosting their cultural relevance. In Chilean context conservation of architectural heritage deals with several difficulties as the seismic conditions of the country, the absence in recent decades of a central policy related to urban regeneration and the accelerated urban development that took place in local cities.

The first legislation at a national level in Chile concerning conservation of properties and sites of cultural interest was passed in 1925 (Vergara, 2018, p. 166). De la Cerda (2012) observes that this initial legal framework actually originated some years earlier, in 1910, with the presentation of a bill for the conservation of monuments. This development coincided with celebrations surrounding the centenary of the First Government Junta in 1810 (De la Cerda, 2012, p. 15).

The 1925 legislation gave legal protection to cultural heritage, and at the time focused on the concept of the monument. In the same year there was the creation of the National Monuments Council, a body responsible for conservation of the country's cultural heritage (Prado and Ossio, 2008, p. 32). The Council continues to oversee protection of architectural heritage, guided by the National Monuments Law of 1970.

Nowadays architectural heritage in Chile can be safeguarded at a national or at a local level, in a case by case authority's evaluation process. Today, the National Monuments Law establishes the safeguarding of 'national monuments' the length of the country (Ley N° 17.288, 1970). At the local level, the General Law on Urbanism and Construction enables the protection of 'Conservation Properties and Areas' by means of local regulatory plans (Decreto con Fuerza de Ley N° 458, 1976). These laws set out the selection process for the conservation of buildings and areas based on criteria with which to categorise their value (Correa et al., 2018, p. 121). The national monuments law declares of interest historical, artistic and commemorative aspects on cultural heritage. This process can leave some historical buildings out of protection, if they are not yet identified, or if they are not considered as valuable cultural sites.

The availability of funding for interventions to and restoration of heritage buildings has increased over time. Recent sources have included the Ministry of Public Works' heritage promotion programme (operational since 2007), the Ministry of Housing and Urban Development's heritage reconstruction plan (operational since 2011) (Torres, 2014) and the National Council of Culture and the Arts' Cultural Heritage Fund (Consejo Nacional de la Cultura y Las Artes, 2017, p. 39). The latter two programmes targeted the recovery of buildings damaged by the 2010 earthquake, which caused extensive destruction to local heritage.

Despite the considerable increase in the scope of heritage conservation in recent decades, there are still numerous heritage sites across Chile that lack legal protection (Consejo Nacional de la Cultura y Las Artes, 2017, p. 63). An unprotected building is at risk of disappearing despite its age or cultural relevance.

The proposed project to regenerate the city of Melipilla's former prison focuses on a site of considerable heritage value and age that has, nevertheless, never been granted heritage status (CIP N° 0412, 2021).

The present intervention proposal proposes a viable plan for architectural regeneration of the site as the basis of its future protection, conservation and management. The project also constitutes an opportunity to reintegrate this interesting site into its city by bestowing renewed cultural and technological purpose upon it.

The former Melipilla prison

Melipilla lies to the south-west of Santiago in the Metropolitan Region of central Chile, and is both a district and provincial capital. The city was founded by Spanish colonial Governor Manso de Velasco during the eighteenth century. Today it is an important satellite city of Santiago. According to the 2017 Census, the district of Melipilla had a population of 123,627 inhabitants, a number that was expected to rise to 143,779 by 2021 (Censos de Población y Vivienda, 2021).

The proposed Melipilla prison regeneration project, seeks to open up an old city-centre building that was traditionally closed to the public and is currently not protected by conservation legislation. Despite its antiquity, architecture, and memory aspects, this building has been neglected for many years.

Melipilla prison is abandoned and has been disused for many years. The project seeks to integrate it once again into the city, opening its spaces up to the community and giving them new uses. The proposed interventions follow criteria of respect for the existing structure and conservation of its historical, architectural and urban value.

Abandoned prisons are urban landmarks that bear a heavy historic and social burden and leave a mark on the community. Former prisons can be found in the historic centres of cities the length of Chile, including in Punta Arenas (Matus, D., and Cvitanic, B., 2017, p. 1), San Fernando (Rutllant da Cunha, N., 2018, p. 1), La Serena, and Melipilla. With the passage of time and urban expansion, new confinement facilities have been created on the outskirts of populated areas. This gradual transition to new infrastructure has left behind old, now disused prisons in the heart of many cities. These sites, a testament to history and built to a structural design appropriate to their function, now lie disused, despite their central location and connection to strong networks of infrastructure and services (Figure 1). The former prison in Melipilla was built at the end of nineteenth century (Torres, G., 2022, p. 5) and located on the same block as the city court and the cathedral, opposite the *Plaza de Armas*, or main square (Figure 2). Without the legal protection afforded to heritage sites, the building is now at risk of disappearing.

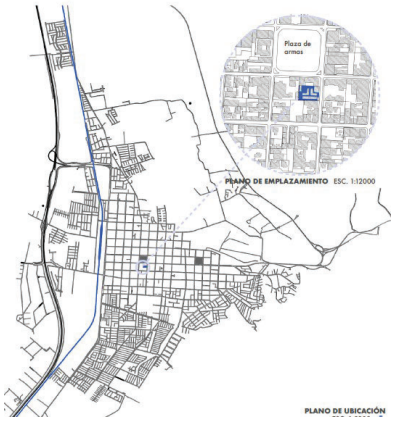


Figure 1: City of Melipilla and the location of the former prison.

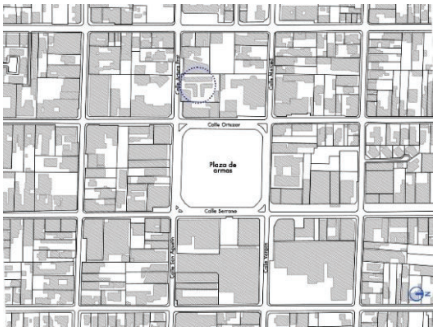


Figure 2: Location of the old prison in Melipilla city centre, near to the main square.

The architecture of the former prison is typical of others of its type. It is built around a central corridor that connects the prison cells and helped to ensure security by controlling the movement of inmates. Construction at the site took place in three stages as the facility evolved over time. Stage one consisted of the main cell block. The walls are built of hand-made bricks using the English bond technique and measure 60 cm wide by 300 cm high. The building consists of 31 prison cell modules and two corridors connecting perpendicularly to form a T (Figure 3). French architect Henri Poussin proposed that a linear configuration offers practical advantages in terms of illumination, ventilation, sunlight and security (Altmann. J., 1970, p. 63).

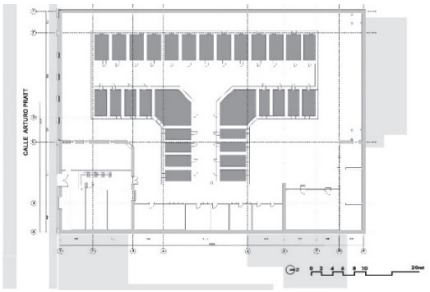


Figure 3: Current floorplan.

The cell wings are arranged and connect perpendicularly to a central corridor, providing favourable environmental conditions and simplifying the movement of inmates along an established route (Altmann. J., 1970, p. 63) (Figure 4). It should be mentioned that other architectural ideas for confinement facilities had been developed prior to this. Published in 1780 by Jeremy Bentham, "The Panopticon" sets out an architectural prison design that permits visual control of the entire facility from a central tower (Figure 5-6). Control of inmates was ensured by the existence of a single corridor running the length of the building. This main passageway constitutes the only internal access route connecting the cell blocks. The cells themselves are accessed via flat-arched openings that can be seen beneath the plaster and are part of the original structure (Figure 7). The second stage was added to the prison in the mid-twentieth century and involved the construction of 2-storey structures within the compound: one along the southern façade and accessible from the street via a single door, and the other along the northern façade (Figure 8).

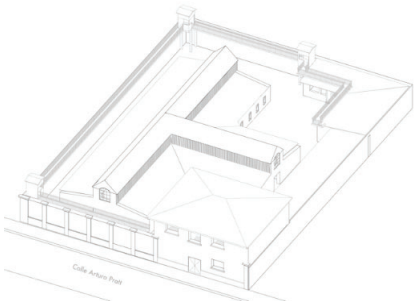


Figure 4: Original configuration (inferred).

Figure 5: Eastern façade in its original state.

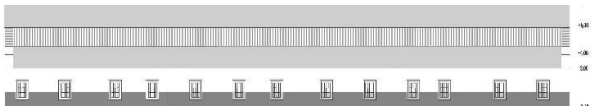


Figure 6: Western façade in its original state.

The third stage, implemented at the end of the twentieth century, consisted of lightweight materials added to form extensions and annexes to the cell block and common areas, providing additional facilities for the inmates (Figure 9). These additions are not considered of relevance to the historical building in its original form and were built straight onto the compound's open areas. The proposed project faces two challenges: the first is the material recovery of an abandoned building that occupies an important place in the memory and history of the local community; the second is to assign the site a new, contemporary function compatible with the existing architecture, establishing criteria of respectful intervention and highlighting the value of this historical building (Figure 11-12). To this end, we make use of digital design tools to aid decision-making, focusing on energy conservation and sustainability in addressing the question of climatization and minimising the impact of the intervention on the existing architecture.

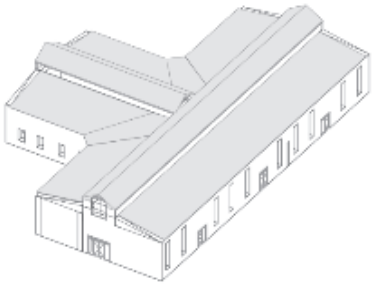


Figure 7: Stage one of construction: the main cell block.

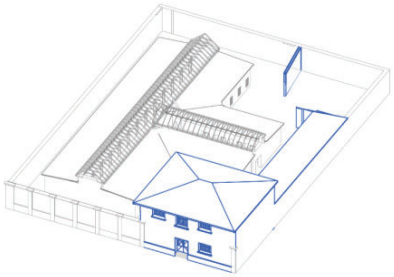


Figure 8: Stage two of construction.

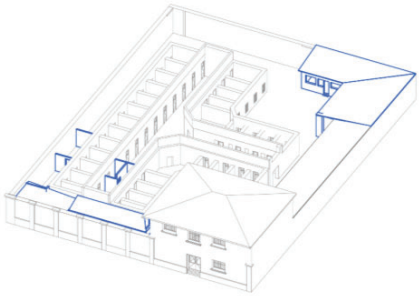


Figure 9: Stage three of construction.

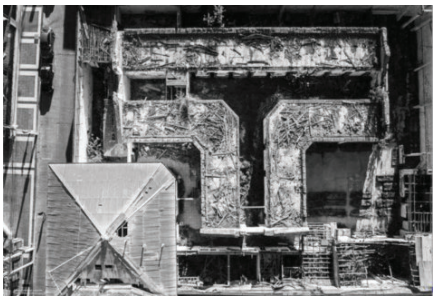


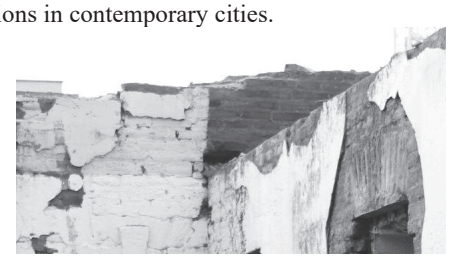
Figure 10: Current state of the former Melipilla prison.

From prison to library

Melipilla currently has a small library in the city council building. However, the room was not designed for this purpose and lacks the necessary space for it to adequately fulfil its function. A new city library would bring considerable benefit and provide a new cultural space for the local community. The city council has identified the site of the former Melipilla prison as a suitable location for a new public library. The project would help to preserve one of the city's historical buildings and to promote its heritage value by opening it to the public. The proposed project consists of the creation of a library that would be open to the community and highlight the heritage value of this historical building and its memory, adding a book-café, reading areas and a patio. The design would take into consideration the site's history, assigning it a new function and providing the city with a new public space.

The regeneration project

Proposals to convert former prison buildings into cultural facilities for use by the general public have been seen the length of Chile. One example is the proposal to transform the prison in Punta Arenas into a library and regional archive (Aguilar, R., 2017). Another recent and notable example of the regeneration of a historical city-centre prison in Chile, and one which bears considerable resemblance to the former Melipilla prison, is that of La Serena. The site dates back to the late nineteenth century and was successfully restored and reopened as a therapeutic assessment centre, thus demonstrating the feasibility of adapting old buildings of this type to new functions in contemporary cities.



Figures 11: Current state of the former Melipilla prison.

Figures 12: Current state of the former Melipilla prison.

As with these other examples, the Melipilla prison regeneration project seeks to renovate the existing building, making the necessary modifications to adapt it to its new function in a manner that respects its heritage status. The project proposes a conceptual shift from confinement to openness, providing a new urban public space that is accessible from the street. The old cell block will be renovated and more recent modifications will be removed in order to reflect the building's original design. Access to the site is via a public square, which includes a new structure to house a café, auditorium and other facilities, thus complementing the library space provided by the repurposed prison building. The various aspects of the intervention will be respectful of the existing structure, emphasizing the original materials used and relating it to its immediate context. Crucially, the proposal adapts the existing space to its new function, modifying certain elements in order to reconfigure the space, while exposing traces and testimonies of the site's history as a prison and highlighting the authenticity of this old building.

The existing building will be renovated and spaces will be connected in order to convert the old prison cells into reading rooms. The original spatial configuration of some of the cells will be left intact as testimony of the past (Figure 13). Others will be modified and joined together

in order to open up the space and adapt the building to its new function (Figure 14-15). The project involves the following intervention criteria:

Respect: The project respects the historic building, emphasising the original materials used and the traces of its history (Figure 16). The structure is adapted to its new function while maintaining its original corridors and preserving some of the old prison cells as testimony of the past (Figure 17).

Authenticity: A key objective of the project is to preserve the historic fabric of the building, carrying out respectful and restrained interventions. Annexes and extensions that are not in keeping with the original structure will be demolished in order to focus attention on the old cell block (Figure 18).

Functionality: The building will be repurposed and the necessary interventions made to ensure the effectiveness of the proposed project. Certain closed-off areas are to be opened up and spaces joined in order to adapt the building to its new function. The original fabric remains in evidence and the memory of the site is preserved (Figure 19).

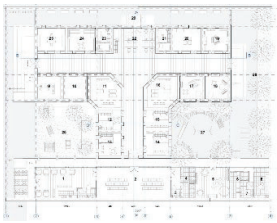


Figure 13: Proposed layout.

Figure 14: Proposal, Section C.

Figure 15: Proposal, Section A.

Figure 16: External view of the proposed access square.

Figure 17: Proposed interior north patio.

Figure 18: Internal view of the proposed central corridor.

Figure 19: Internal view of the proposed central corridor.

Energy retrofit

Refurbishment of the former prison building will include the implementation of a passive ventilation system in order to maximise energy efficiency and adapt the various spaces to their new function (Figure 20). The proposed project takes into consideration local wind speed, temperature, façade material and orientation, and internal ventilation and illumination requirements, moreover the excess heat will be dissipated by means of the stack effect (Figure 21-22). The proposal involves covering the old central corridor with a translucent roof to allow the passage of light. The addition of a solar control film will prevent glare during the most intense hours of sunlight (Figure 23). This technology helps to reduce radiation and heat, filtering excess light and ensuring that the corridor remains comfortable. The old prison cells will become reading rooms and study areas. All rooms will be shaded from excessive light streaming in through the roof by means of a perforated latticework that will filter the light as it enters from the corridor.

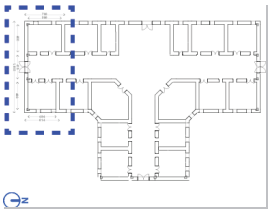


Figure 20: Analysis zone.

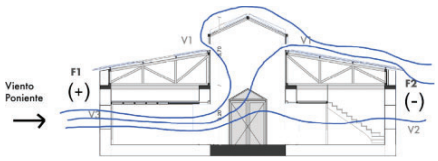


Figure 21: Ventilation plan with stack effect.

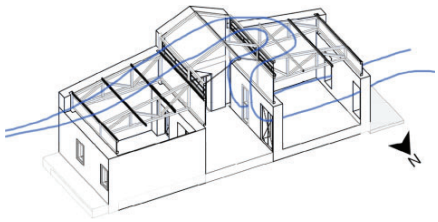


Figure 22: Ventilation plan.

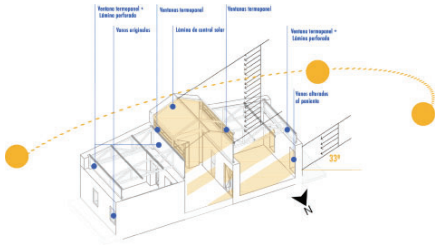


Figure 23: Daylighting of the indoor spaces.

In order to achieve thermal comfort during the winter, an analysis was made of those parts of the building most susceptible to energy loss. Double glazed windows will be installed in the original openings and in the gap between the roof and the original walls (Figure 24). In order to control excessive solar gain during the summer months, the windows in the central corridor will open automatically to enable the stack effect to exhaust heat from the building, thus ensuring thermal comfort inside (Figure 25).

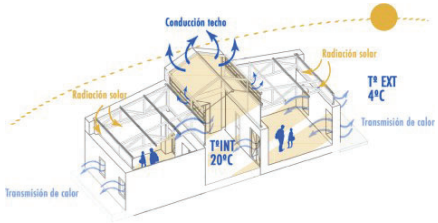


Figure 24: Winter functioning.

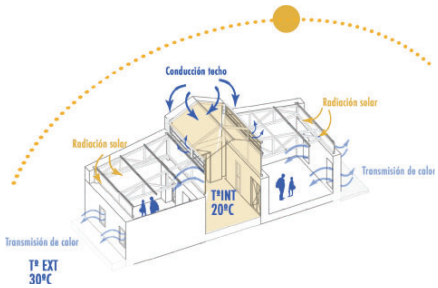


Figure 25: Summer functioning.

Digital Twin approach and automation

The proposed building renovation system maximizes the comfort of the library users while minimizing energy use through passive solutions, in order to maximize the building's sustainability. As demonstrated in (Tagliabue L., 2021), the ability to monitor various parameters of buildings for public use allows for maximum sustainability and, as an additional benefit, users' comfort. One of the most popular approaches today uses the technology provided by the Internet of Things (IoT) to collect and organize information about the state of the building in what is known as a Digital Twin in the scientific literature. From an IoT perspective, building automation involves using connected devices and sensors to automate and optimize the operation of various systems within a building. These systems may include lighting, heating, ventilation, air conditioning, security, and energy management. By integrating these systems and leveraging data collected from sensors and devices, building managers can gain insights into the building's performance and make data-driven decisions to improve efficiency, comfort, and safety. Figure 26 shows the typical layered structure that describes the flow of information from the lowest level, the physical one, up to the application level, where the information is used.

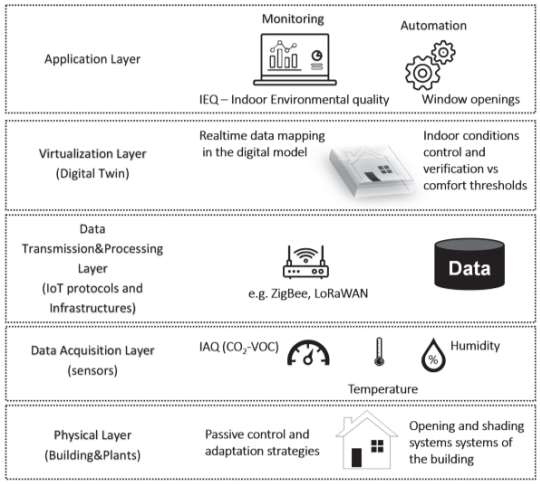


Figure 26: Proposal for digital twin architecture

The layered organization allows each layer to use the services of the previous one without knowing the implementation details, facilitating the integration and development of new services. There are five layers ad described in the following:

Physical Layer: The physical layers includes the building and all of its plants. The physical layer is the primary information source.

Data acquisition Layer: The data acquisition layer is comprised of all electronic systems capable of connecting the physical and virtual worlds. Sensors and transducers, which allow information from the physical world to be acquired, are part of this level. The types of sensors that can be installed inside buildings are determined by the application. Sensors for monitoring environmental comfort, such as temperature sensors, relative humidity,

CO2, Volatile Organic Compound (VOC), illuminance sensors, and sensors for monitoring energy consumption, are examples of sensors that can be installed in the building for enabling the control of the above described dynamic behaviours (e.g. opening and closing the clerestory, activation of shading systems etc.).

Data Transmission and processing Layer: This layer is in charge of collecting data from sensors and transmitting it via IoT protocols to infrastructures that are in charge of storing the data collected by sensors from the physical layer. This level is the IoT paradigm's infrastructural heart.

Virtualization Layer: The information collected, processed, and stored by the previous layer is used by the virtualization layer, which is responsible for modeling the sensorized building's behaviour. The virtualization layer is the foundation of the Digital Twin concept, which is the representation and virtualization of the physical world. The Digital Twin is the key component that enables applications, users, and services to access information from the physical world, i.e. the building.

Application Layer: This layer enables the creation of services that make use of the previously virtualized building information. Different services can be defined and implemented at the application level, which can be addressed to the technical staff who deal with building maintenance and management, as well as to the people who use the sensorized building.

As previously stated, this is a very flexible and general architecture that lends itself to the development of various systems. The type of sensors to be installed in the building in the case under consideration is determined by the applications to be developed. It is possible to increase the number of parameters to be monitored later by utilizing IoT communication systems provided by the Data Transmission and processing layer. The installation of temperature and humidity sensors to estimate room comfort is the bare minimum of sensors envisaged during the building restoration phase. Two main services are envisaged at the application level: comfort monitoring and automation. The monitoring application in the first case are primarily aimed at building management technicians. The technicians can validate the comfort inside the rooms while also ensuring their sustainability by defining appropriate Key Performance Indicators (KPIs). The automation application, on the other hand, is concerned with managing the actions that the proposed system is capable of performing on some of the building's systems, particularly the central body's windows, which can be opened to allow for ventilation. The windows are opened and closed based on the information obtained from the sensors installed inside the building and using weather information. I.e. if rainstorm are expected, the automation will not open the windows.

Conclusions

Buildings serve to reflect a city’s past and help us to understand their landscapes over time. Built heritage reflects a particular culture, its traditions and its modes of life. The relationship between past and present is ongoing, and architecture, as a discipline, deals with both (Atria, 2015). It presents the opportunity to repurpose old buildings, adapt their spaces, and embrace new histories that strengthen their cultural relevance. Buildings reuse is relevant, and a part of a sustainable perspective in planning the cities future, related to saving and optimizing existing resources. The use of IoT technology during building refurbishment provides several benefits in terms of sustainability while lowering operational costs: Energy Efficiency; Enhanced Comfort; Predictive Maintenance Remote Monitoring and Management. Today, architectural heritage is protected and promoted, and current technologies and digital design tools can be applied to projects such as this with interesting results. In addition, implementation of automated systems reduces to a minimum the impact of interventions to cultural heritage increasing the possibility to comply with current energy saving ad IEQ standards for new buildings that are not trivial to obtain in historical buildings. The Digital Twin approach can be verticalized and directed to specific purposes in the renovated buildings, supporting functionalities that can innovate and repurpose the constructions increasing their sustainability and inclusivity. The automation can enhance the adaptability and resilience of the building to new climate conditions and people flows and the IoT infrastructure can be extended over time to include new field of control as the functions evolve. A dynamic built organism is envisioned to extend the building life and add value to renovation interventions. The field is of considerable interest and presents new perspectives for the research and application of new ways of inhabiting historic buildings.

The renovation of the Melipilla historical building from a prison to a library necessitates careful planning and consideration of a variety of factors. A successful renovation can create a space that is both functional and respectful of the history by taking into account the building's history, the needs of the local community, and modern safety and accessibility requirements. The following are the most critical findings of the Melipilla historical building's renovation from a prison to a library we have faced:

Structural issues: Older buildings frequently have structural problems that we addressed during renovations. In the case of a prison, the building has been designed to be more secure and less welcoming, so changes to make it more welcoming as a library was necessary.

Historical significance: The Melipilla prison building has historical significance, which was both a challenge and an opportunity during a renovation project. Certain elements of the building's original design need to be preserved while also being adapted to meet the needs of a modern library.

Safety and accessibility: When renovating a historical building, modern safety and accessibility requirements must be met. For example, the building need to be brought up to fire safety code, or ramps and lifts are required to make the library accessible to people with disabilities.

Community engagement: The renovation project of the Melipilla building provided an opportunity to engage with the local community and solicit feedback on how the building should be used.

Elements of design: The design of a library is important for creating a welcoming and functional space for visitors. We need to consider how to use the existing space in a way that maximises natural light and creates a comfortable environment for reading and studying when converting a prison into a library.

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