Politecnico di Torino

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Revitalization of the former Benedettine church in Piacenza

Conversion into a music auditorium and multipurpose exhibition space

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00 Abstact

The regeneration of degraded spaces is the most concrete expression of sustainability: it conserves building capital, avoids new construction, reduces land consumption and embodied carbon emissions and returns use value to the community.

The reuse of the former Benedictine Church is the objective of this thesis. The project focuses on the functional redesign of the building, but at the same time opens up broader scenarios of urban regeneration, with the aim of restoring value to an area currently characterised by neglect, decay and a general state of decay.

The project aims to create a unique auditorium, designed to host musical, cultural and performing arts events, in line with the history and spirit of the place. This space also includes an exhibition area, which guides visitors on an immersive journey, highlighting the architectural beauty of the church and narrating its identity.
The exhibition hall and auditorium coexist in a single, flexible environment, designed to adapt to the different needs that the city may express over time.
This adaptability is not only a design choice, but a thread that runs through the building's entire history: over time, the church has always changed its function of use, each time responding to the different needs of society. Over the centuries, it has been transformed from a place of worship to a military depot and then to a governmental defence space.

Today, with this new project, there is an opportunity to return it to the community as a living, accessible place, rich in memory and ready to welcome new forms of expression, without covering up the signs of time with the intention of keeping alive the memory of the history and periods that have characterised the building's life.

La rigenerazione degli spazi degradati è l'espressione più concreta della sostenibilità: conserva il capitale edilizio, evita nuove costruzioni, riduce il consumo di suolo e le emissioni di carbonio incorporate e restituisce valore d'uso alla comunità.

Il riutilizzo dell'ex Chiesa delle Benedettine è l'obiettivo di questa tesi. Il progetto si concentra sulla riprogettazione funzionale dell'edificio, ma allo stesso tempo apre scenari più ampi di rigenerazione urbana, con l'obiettivo di restituire valore a un'area attualmente caratterizzata da abbandono, degrado e uno stato generale di decadenza.

Il progetto mira a creare un auditorium unico, progettato per ospitare eventi musicali, culturali e di arti performative, in linea con la storia e lo spirito del luogo. Questo spazio comprende anche un'area espositiva, che guida i visitatori in un viaggio immersivo, mettendo in risalto la bellezza architettonica della chiesa e narrandone l'identità. La sala espositiva e l'auditorium coesistono in un unico ambiente flessibile, progettato per adattarsi alle diverse esigenze che la città può esprimere nel tempo. Questa adattabilità non è solo una scelta progettuale, ma un filo conduttore che attraversa tutta la storia dell'edificio: nel corso del tempo, la chiesa ha sempre cambiato la sua funzione d'uso, rispondendo ogni volta alle diverse esigenze della società. Nel corso dei secoli, è stata trasformata da luogo di culto a deposito militare e poi a spazio di difesa governativo.

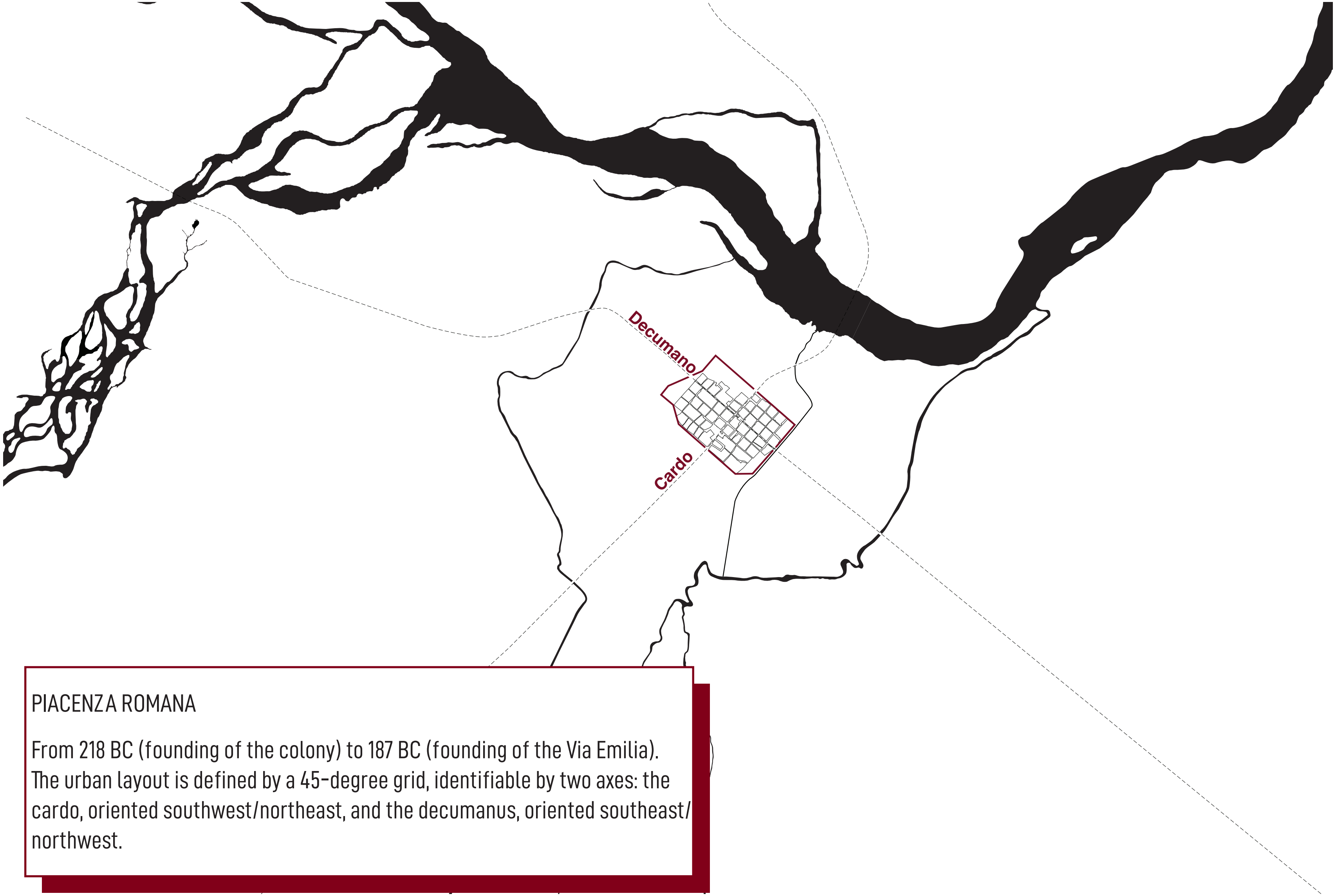
Oggi, con questo nuovo progetto, c'è l'opportunità di restituirla alla comunità come luogo vivo, accessibile, ricco di memoria e pronto ad accogliere nuove forme di espressione, senza coprire i segni del tempo con l'intento di mantenere viva la memoria della storia e dei periodi che hanno caratterizzato la vita dell'edificio.

01. Context and preliminary analyses

01.1 Piacenza - Urban expansion

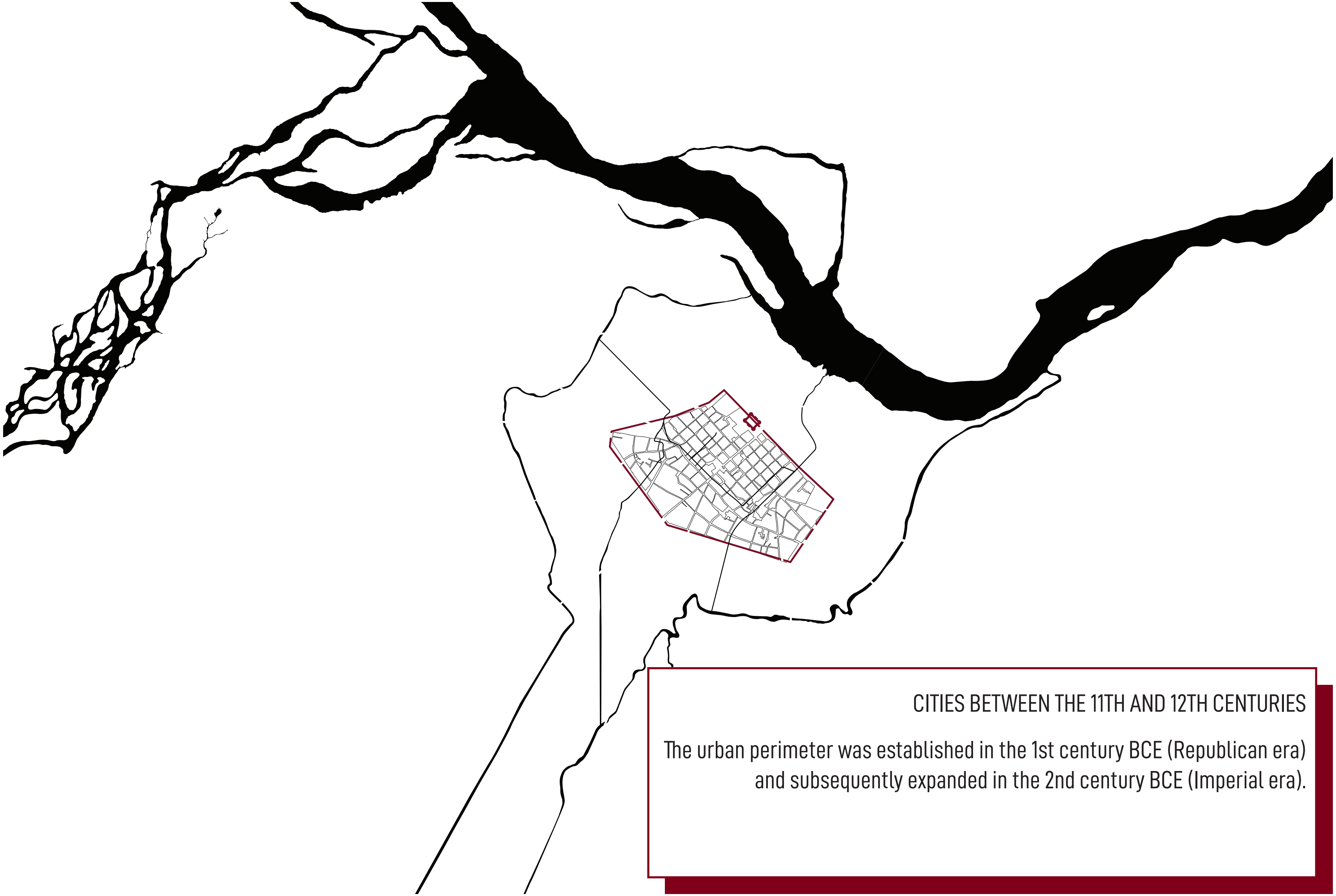
CITY OF PIACENZA

The city of Piacenza has its origins in Ligurian, Etruscan, and Celtic settlements. However, it is challenging to delineate the extent of these historical periods with any clarity or definitiveness. The city of Placentia (lat. late Placentia, "Piacenza," "desire for pleasure") was founded in 218 B.C. by Roman colonists. These colonists settled on the right bank of the Po River, establishing the encampment of Piacenza, and on the left river coast, where they founded Cremona. The city's strategic positioning within favorable territory, de facto Gallic territory, was a deliberate decision to counter and control the local and Carthaginian populations. The city, situated at an elevation of 61 meters above sea level, was strategically positioned above the Po and Trebbia rivers. This advantageous location enabled the city to exercise effective control over enemy forces along the river shaft and the Apennine route. Following the emergence of Christianity in the Roman Empire, which was a gradual process (the first Christian communities formed in the 1st century AD, but Christianity was legalised in 313 AD by Constantine's Edict of Milan and was proclaimed the official religion of the empire in 380 AD by Theodosius I's Edict of Thessalonica), the first places of worship were built in the city of Piacenza: the Basilica of St. Anthony, named after the martyr and patron saint of Piacenza, and the new Episcopal Complex, which became an important centre of religious power. After the fall of the Western Roman Empire in 476 AD, the city was conquered by the Lombards in 739 AD. The Basilica of St. Anthony, dedicated to the martyr and patron saint of Piacenza, and the new Episcopal Complex, which became an important centre of religious power. After the fall of the Roman Empire, urban life passed into the hands of the bighops. In 997, the city was administered by the bishops of the Conti family. Around the same time, Piacenza experienced a strong demographic and economic revival, thanks to its strategic position along the Via Francigena (a medieval pilgrimage route connecting north-western Europe with the Italian peninsula and Rome in particular), used by many pilgrims and merchants. Between the 11th and 13th centuries, during the centuries of communal civilisation that saw Italian cities gain increasing autonomy, Piacenza became a centre of production, especially textiles. Between the 11th and 13th centuries, during the centuries of communal civilisation that saw Italian cities acquire growing autonomy, Piacenza became a centre of production, especially textiles, a financial centre and a centre of trade and commerce. The city's economic growth was also due to the, wealth that allowed the city to expand. In 1545, Pope Paul III Farneseestablished the Duchy of Parma and Piacenza, giving it to his son Pier Luigi Farnese. In Piacenza, the symbol of the family's power is represented by the majestic Palazzo Farnese. The city would be ruled by the Farnese family until 1731. During the 1800s, Piacenza experienced a time of multiple rule, including Bourbon, Napoleonic, and ultimately Austrian. Under Maria Luisa of Austria, the city underwent an extended duration of steadiness. In the early 20th century, there was a two-decade phase of construction stagnation. The economic surge took place after the two world wars, leading to nearly a doubling of the developed area of the whole.



PIACENZA ROMANA

From 218 BC (founding of the colony) to 187 BC (founding of the Via Emilia). The urban layout is defined by a 45-degree grid, identifiable by two axes: the cardo, oriented southwest/northeast, and the decumanus, oriented southeast/northwest.



CITIES BETWEEN THE 11TH AND 12TH CENTURIES

The urban perimeter was established in the 1st century BCE (Republican era) and subsequently expanded in the 2nd century BCE (Imperial era).

MEDIEVAL PIACENZA

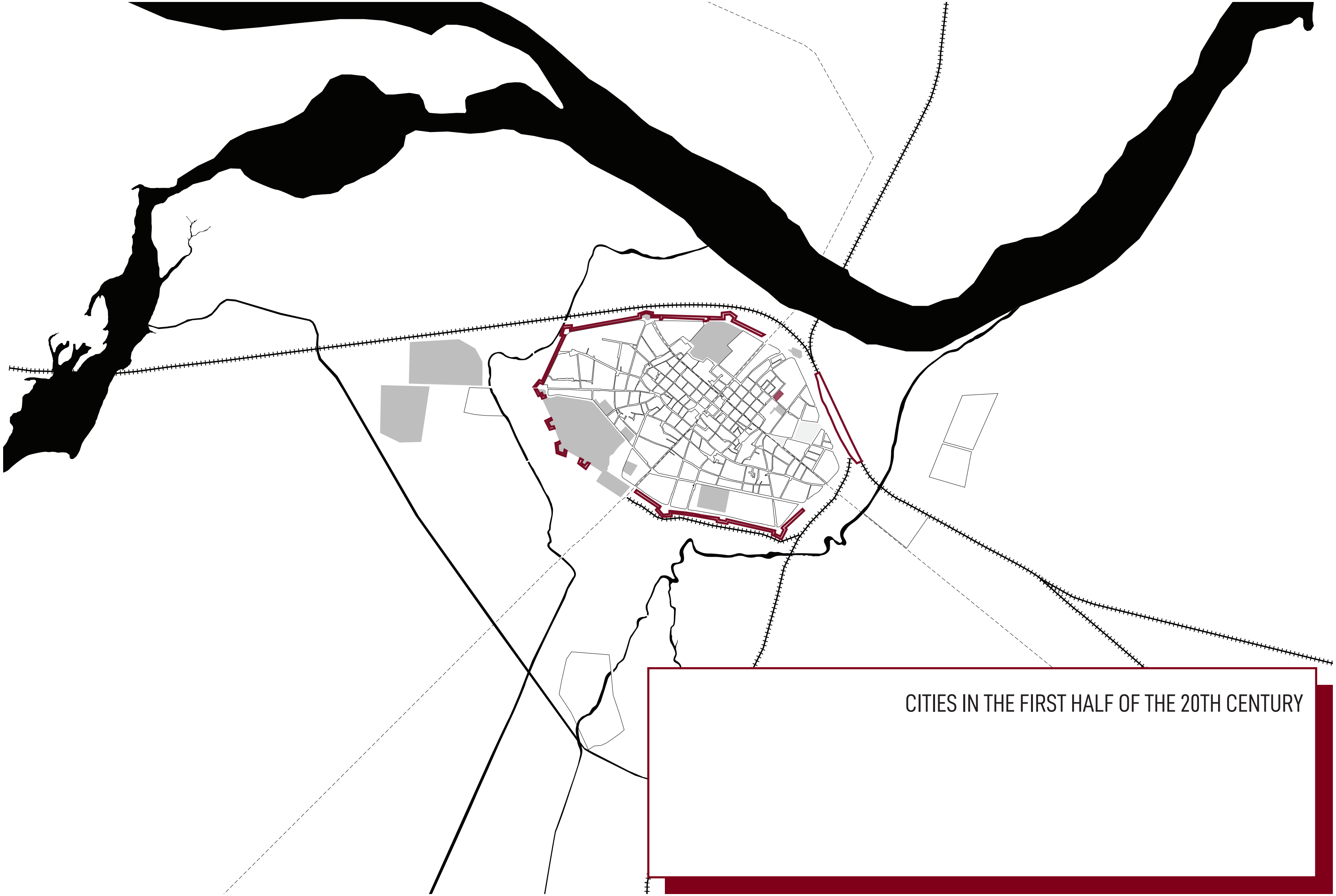
From 962 AD (fall of the Roman Empire) to the beginning of the 16th century (Sforzesco government)

CITIES IN THE 15TH CENTURY, RENAISSANCE PIACENZA

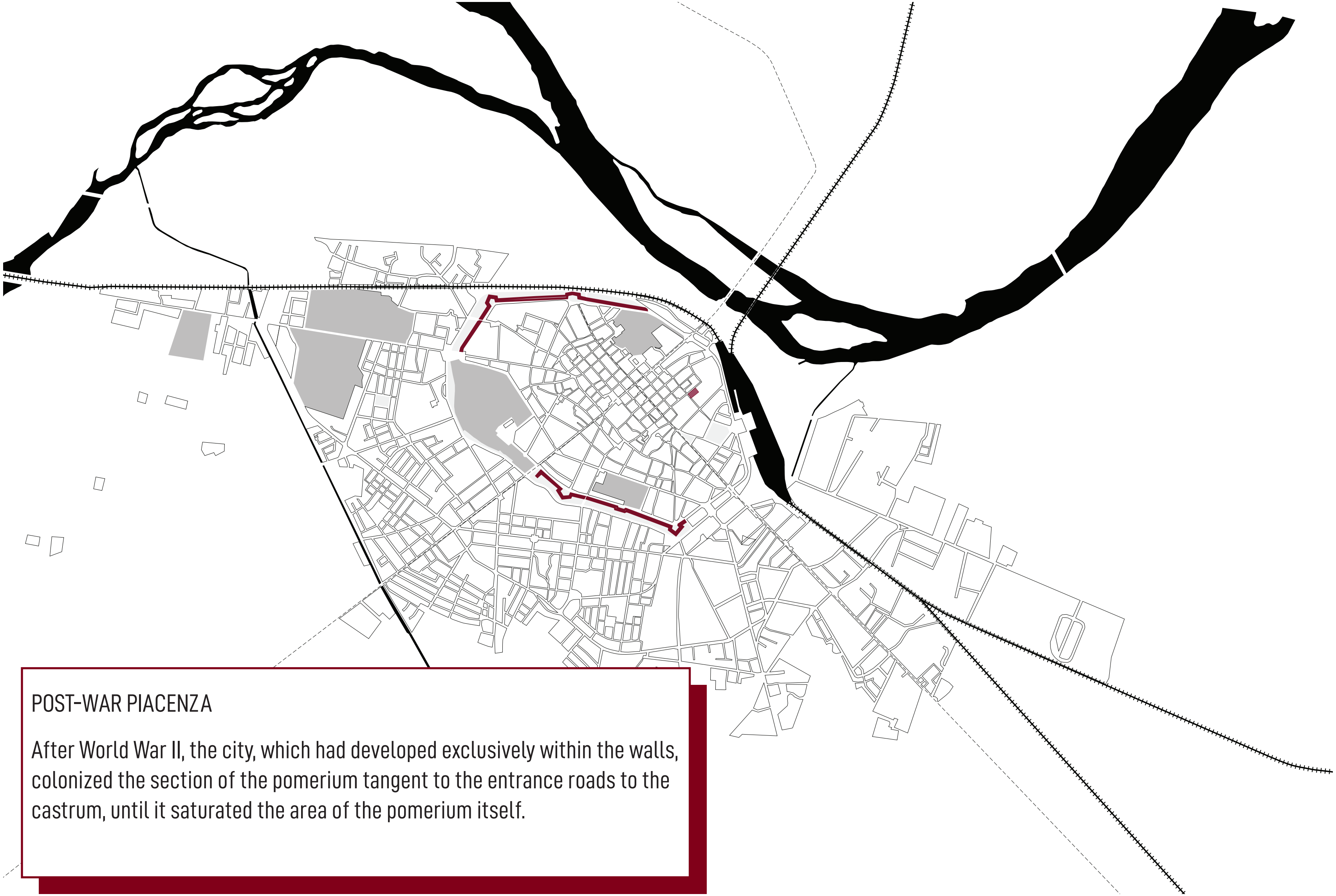
The conclusion of the period marked by a logic of maintenance of the fortifications led to a new design phase, which saw Sangallo the Younger carry out a reorganization of the perimeter space in 1531.

CITIES IN THE 19TH CENTURY

The Farnese walls were supplemented in 1820 with an outer barrier, 1,500 meters away, consisting of moats and embankments with internal brick supports.



CITIES IN THE FIRST HALF OF THE 20TH CENTURY

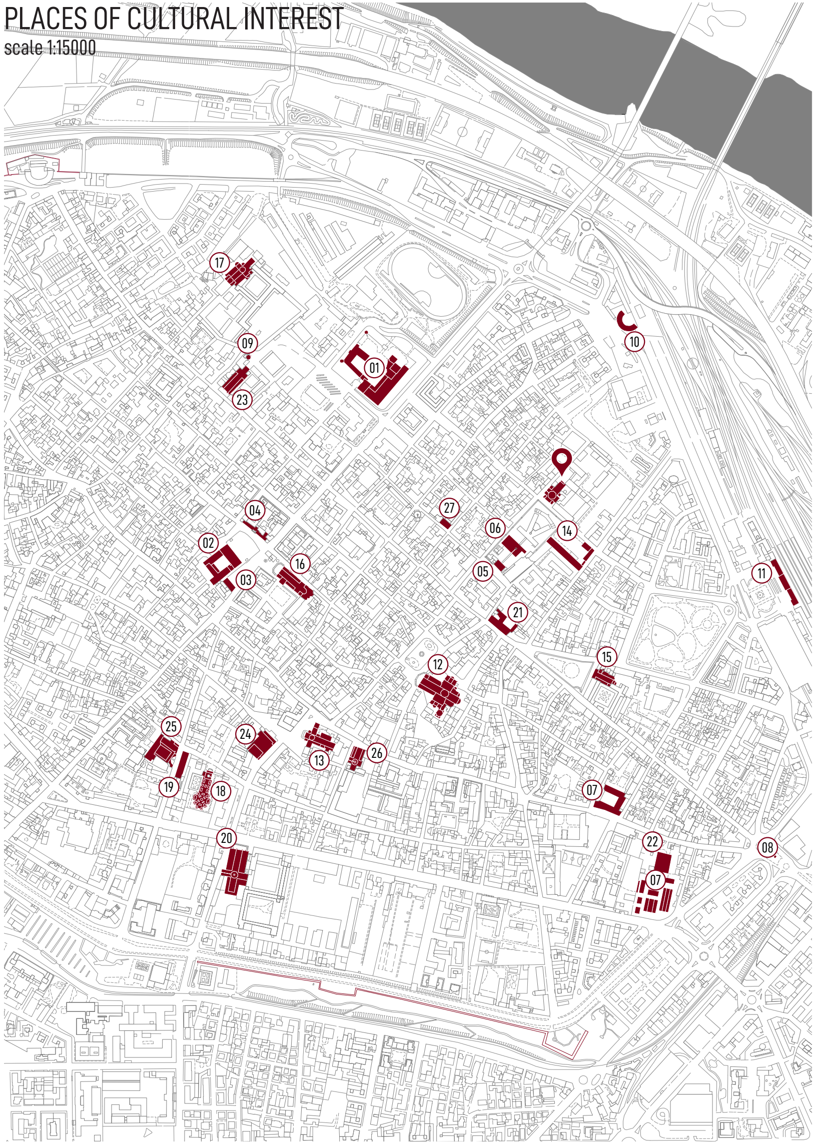


POST-WAR PIACENZA

After World War II, the city, which had developed exclusively within the walls, colonized the section of the pomerium tangent to the entrance roads to the castrum, until it saturated the area of the pomerium itself.

PLACES OF CULTURAL INTEREST

scale 1:15000



HISTORICAL BUILDINGS

01 Palazzo Farnese
02 Palazzo Gotico
03 Palazzo dei Mercanti
04 Palazzo del Governatore
05 Palazzo Landi
06 Palazzo Madama
07 Politecnico of Milano
08 Monument alla Lupa
09 Casa del Mutilato
10 Torrione Fodesta
11 Train station
14 Stables of Palazzo Madama

CHURCHES

12 Duomo – Cathedral
13 Sant'Antonino
15 Basilica of San Savino
16 Basilica di San Francesco D'Assisi
17 Church of San Sisto
Former Benedettine church

MUSEUMS

01 Palazzo Farnese
18 Ricci Oddi
19 XNL Piacenza
20 Former church of Sant'Agostino
21 Palazzo Costa
22 Natural science museum
23 Former church of Carmine

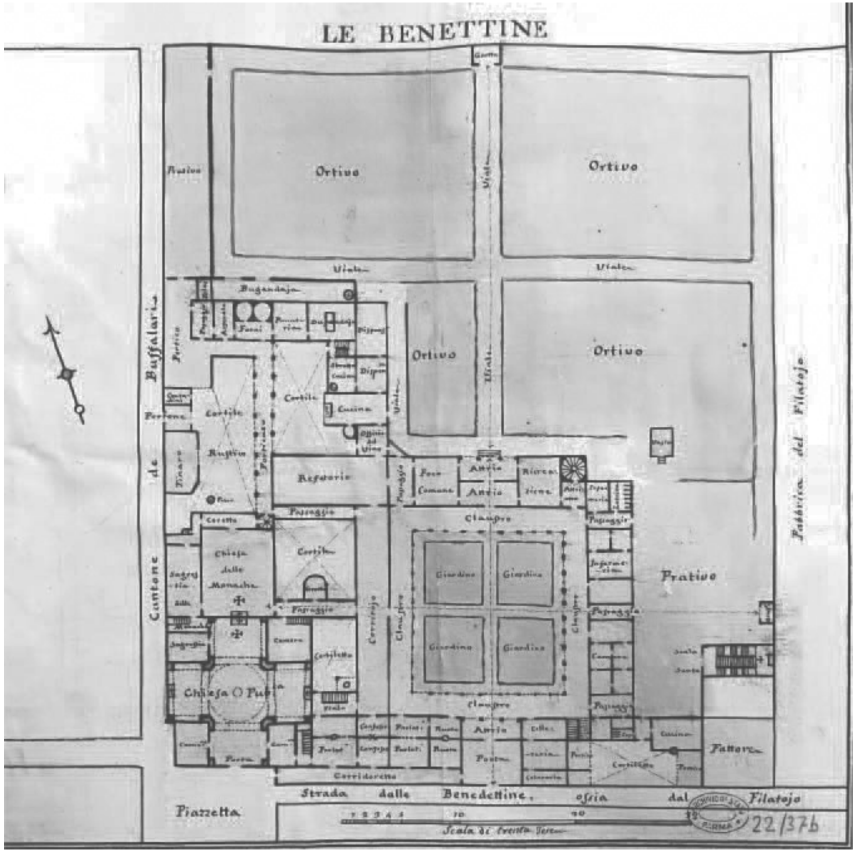
THEATERS

24 Teatro Municipale
25 Teadro dei Filodrammatici
26 Sala dei Teatini
27 Teatro Gioia

01.2 Ex-Church of the Benedettine

The seventeenth century was a century characterised by great upheavals, both political and religious. The already tense climate of the sixteenth century, made even more unstable by the Catholic Counter-Reformation, exploded at the beginning of the century with the outbreak of the Thirty Years' War, which saw the greatest European powers clash. The hostilities, remembered by posterity as some of the bloodiest and most devastating in the entire history of the continent, ended without a winner in 1648 with the Peace of Westphalia. This conflict, combined with other commercial and religious factors, marked Italy's definitive decline in the European political arena. The peninsula, now prey to foreign monarchies, went through a serious period of political and economic crisis, but also a health crisis, which culminated in the plague epidemic of 1631. Like all Italian states, the Duchy of Parma and Piacenza also found itself facing a very complicated situation. While remaining neutral in the struggle between France and Spain, it had to defend itself from the expansionist ambitions of the Papal States towards the Duchy of Castro (a territory belonging to the Farnese family since 1154), which in 1649 became the property of Pope Urban VIII. Furthermore, in 1646, Duke Odoardo I died suddenly, leaving power in the hands of the then 16-year-old Ranuccio II. The war against the Papal States drained the ducal coffers, and the young sovereign, in addition to a difficult economic situation, also had to face a much more personal problem. In 1668, following the death of his second wife, Ranuccio II married Maria D'Este, but she, like his two previous wives, fell seriously ill. The Duke, now without hope, turned to Father Eliseo, who told him that a Benedictine nun had received a divine revelation: if the Duke founded a monastery of the Order of St. Benedict, the Duchess would not only recover her health, but would also be favoured in the succession. Thus, on 26 August 1677, based on a design by the then court architect Domenico Valmagini, the first stone of the Benedictine Church was laid. Beyond the evocative narrative, the real reasons for the construction of this sacred building were actually much more rational. Ranuccio decided on an urban intervention of high political and symbolic value: a "Farnese" axis set to the east on the Palazzo Madama - new monastery axis and with the great backdrop of Palazzo Farnese (to which the Ducal Theatre had been added in those years) at the opposite end: an axis, in fact, capable of structuring and redeveloping an entire city district. This urban project remained unfinished, but it is possible to appreciate the importance attributed to it by the Duke by observing the numerous projects he had carried out and compared for the construction of the monastic complex. Four years after work began, on 31 August 1681, in the presence of Bishop Gaetano Garimberti, the church was solemnly consecrated, and in September of the same year, the nuns moved in. The monastery retained its monastic functions until 1810, when it was deconsecrated and requisitioned by the Napoleonic government to be converted into barracks and a military depot. The former monastery was also closed to the city for the spaces that had previously been accessible: those of the "public" church.

View of the Farnese axis on a historical map of Piacenza, with
the Benedettine Church, Palazzo Farnese, and Palazzo Madama highlighted.

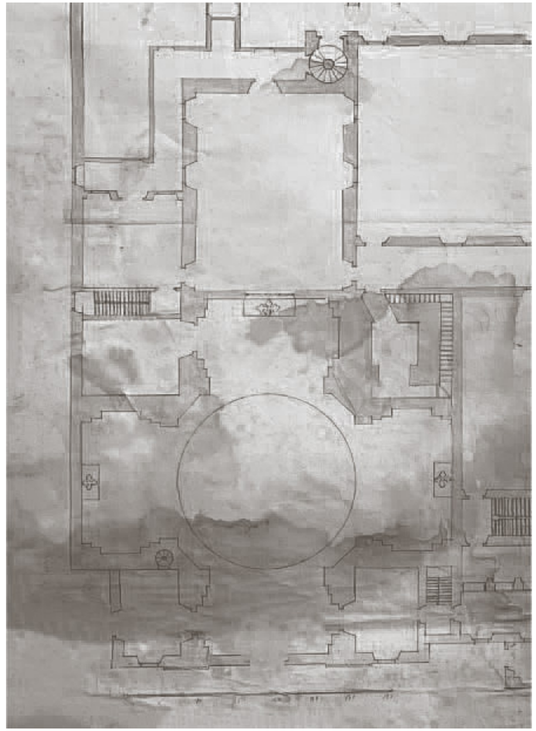


Cadastral plan of the Benedettine monastery

THE DOUBLE CHURCH

One of the recurring features in all the projects presented to Duke Ranuccio II was the presence of a church reserved for nuns. This church was accessible only to those who lived in the monastery, while the public church was intended for the town community. This configuration, called the "Double Church," was developed in religious circles where, in addition to welcoming the faithful for liturgy, it was necessary to ensure that the nuns or monks maintained their vow of cloistered life. Therefore, the concept of the double church is based on the juxtaposition, both longitudinally and transversally, of two liturgical areas: one for the cloistered faithful, normally characterized by simple volume, structure, and decorations, and one reserved for the public, which instead featured more complex and challenging designs. This organization, first introduced in Milan in the 16th century, then developed to acquire the characteristics described above and was quickly adopted in other parts of Italy. This diffusion seems to represent a phenomenon of institutional culture at a supra-regional level, capable of exchanging experiences in distant geographical areas, operating beyond the individual local identities of the cultural context.

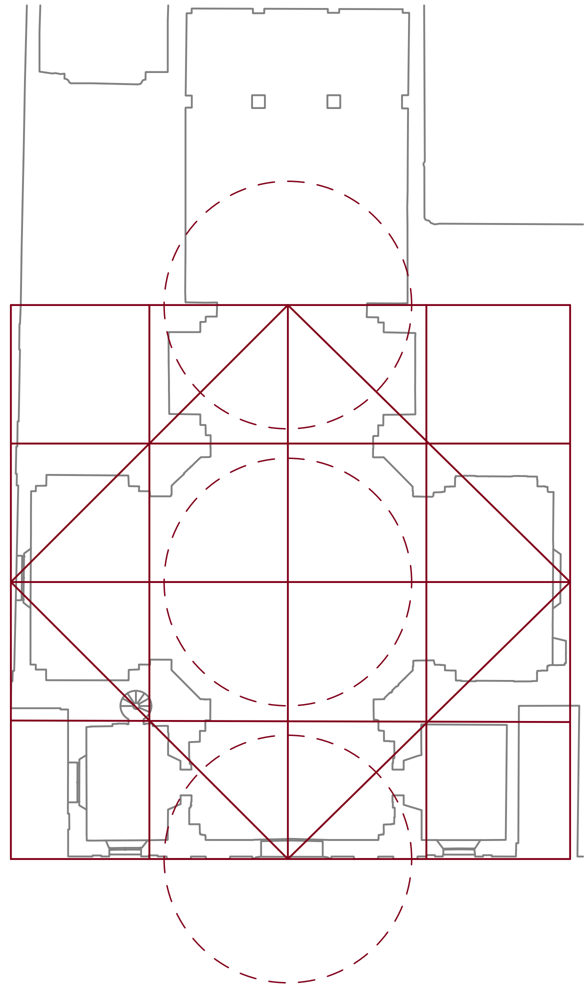
In the city of Piacenza, there were several monastic complexes that featured the 'Double Church'; among the main examples we can mention: the church of the Teresians, the church of the Dominicans in S. Bartolomeo Vecchio and that of the Cistercian nuns in S. Raimondo. The church of the Benedictines, in Valmagini's final design, also features this peculiarity. The court architect's idea for the space assigned to the nuns was a large rectangular room without chapels and with a single altar. The sculptural and pictorial decorations were compromised due to military occupations, which transformed the place of worship into a warehouse, connected to the public church along its longitudinal axis.



Domenico Valmagini's planimetry

BENDETTINE CHURCH

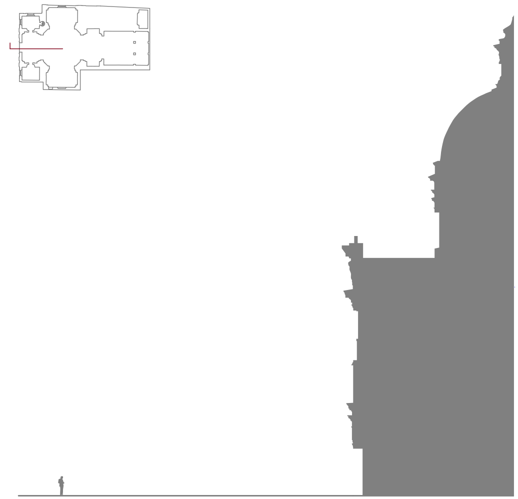
With the aim of creating a church that adhered as closely as possible to post-Tridentine liturgical principles, Domenico Valmagini designed a central Greek cross plan inserted into a square, consisting of two minor altars positioned on the sides, while the high altar was located in the arm opposite the entrance to the building. This layout immediately proved to be very much in line with the architect's aspirations, as this configuration, widely discussed during the Renaissance, is the only one capable of effectively combining functionality and quality of space. A geometric analysis of the architect's original drawings, available in the Parma State Archives, shows that the arms of the cross are approximately one-third the width of the side of the square in which the church is contained; the number three is not just any number, but has a strong symbolic meaning in Christian tradition. Furthermore, the public church was directly connected to the nuns' church through the main altar, and unlike the latter, which appeared very austere in both its layout and ornamentation, it featured a varied decorative scheme enriched with stuccoes, statues and, in particular, frescoes by artists such as Mauro Oddi from Parma and the more famous Ferdinando Galli da Bibbiena. Unfortunately, many of these decorations have been lost today. Finally, the elevation is characterised by a massive octagonal drum, on which stands a large extrados dome, which is unique in the city of Piacenza.



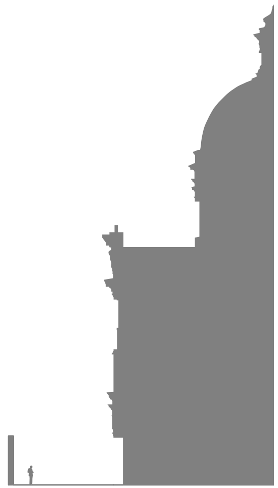
Groundplan of the Benedettine Church in Piacenza
Domenico Valmagini, 1681

THE DOME

The dome of the Benedettine Church represented a true innova-tion for the city. Both at the time of its construction and today, it is the only extrados dome in Piacenza. It is worth mentioning that the Oratory of Our Lady of Guastafredda has a similar roof, but due to its small size, it can easily be overlooked. Its imposing dimensions, which stand out significantly from the rest of the urban context, have taken on significant meaning from both an urban and political point of view. In fact, the church, reaching a height of about 44 metres, has become a landmark visible from most of the city, reinforcing the concept of the urban axis so dear to Duke Ranuccio II, which connected the church to Palazzo Farnese. Unfortunately, today, this visual connection has been lost, both because the work to create the Farnese district was never completed and, above all, because of the presence of new buildings such as the Piacenza courthouse, which have made the church less and less visible within the city. During its con-struction, the Benedictine monumental complex did not overlo-ok narrow streets like the ones today, but a square that allowed the faithful to fully appreciate the grandeur of Valmagini's dome.



Church square, existing until 1682

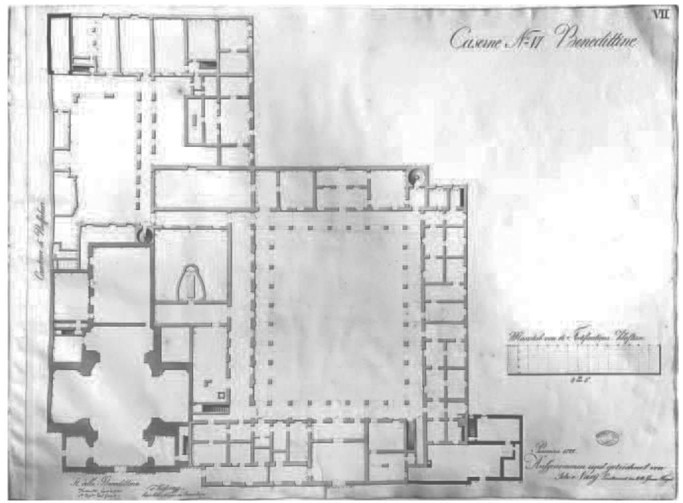


Benedettine street

The dome, with a diameter of 13 metres and a height of about 7 metres, is covered in lead and has eight slightly protruding ribs, surmounted by a lantern on which stands the Farnese lily, symbol of the Farnese family and its political influence on the city. The structure is supported by a tall, sturdy drum which, despite the presence of large windows, provides excellent lighting for the space below. This space, which appears octagonal from the outside, has a large cylindrical body inside, finely decorated with statues and stuccoes, divided by pilasters. The octagonal shape of the drum has a special meaning; in Christian tradition, the octagon is rich in symbolism. This geometric figure, obtained by taking two squares inscribed in a circle and rotating one of them by 45 degrees, represents a bridge between the square (the earthly world) and the circle (the heavenly world). In this church, it therefore becomes the link between the floor plan, a Greek cross inscribed in a square, and the dome, which has a circular shape. Due to the complexity of its execution, particularly in terms of technical and structural aspects, the architect demonstrated a thorough knowledge of all the scientific discoveries of the period, derived both from Renaissance texts such as De re aedificatoria, which offers a detailed analysis of the construction techniques used in the works of ancient Rome, and from the works of mathematicians of the time, whose aim was to abandon the traditional empirical method in favour of a new approach based exclusively on mathematical and geometric principles.

Roof view of Benedettine church

From 1810, the year in which the monastery was suppressed, to the present day, the Benedettine Church has changed its intended use several times, and as a result of these changes, it has undergone transformations that have partially altered its original structure. In 1801, with the Treaty of Aranjuez, the Duchy of Parma and Piacenza came under the control of the French army, led by General Bonaparte. Given its strategic position, at the junction between the Po Valley and Lombardy, the city of Piacenza underwent rapid militarisation, which led to numerous convents and monasteries in the city being transformed into barracks and military warehouses capable of accommodating transalpine troops. The Benedettine complex was not exempt from this fate, and in 1810 saw the expulsion of the order that had been housed there for more than a century. French rule of the city did not last long; following the defeat at Leipzig in 1813, the Napoleonic Empire gradually lost all its Italian possessions, and in 1814 the Duchy was conquered by the Habsburg Empire. The change in city government, however, did not alter the fate of the church, which, as shown in an Austrian cadastral plan from 1822, continued to be classified as a barracks. At present, the layout of the church still appears very similar to its original design. There is a clear formal distinction between the public and private areas of the church, and even the nuns' church remains unchanged in its rectangular shape. It can be inferred that the brick floors had already been removed during the French occupation and replaced with stone, which was much more suitable for use as a military warehouse. The Austrians ruled Piacenza until 26 March 1848, when local unrest, after six days of tension, forced the Habsburg forces to leave the city, which on 14 May of the same year surrendered autonomously to Carlo Alberto of Savoy, thus earning the title of "Firstborn of the Kingdom of Italy". Despite this change of authority, the church, now owned by the military state, continued to serve as a warehouse. The church was further removed from the memory and sight of the inhabitants of Piacenza by the construction of the 19th-century former prison, known as Palazzo Barborini, in honour of the engineer who designed it. This prison, built in the early 1890s, occupied the area in front of the church, where the square opened onto the gardens of Palazzo Madama, definitively nullifying Ranuccio II's attempts to establish a visual link between the church and the ducal residences.



Habsburg cadastral map, 1822

Part of the church also belongs to this historical period and is preserved in the military heritage archives, where it is possible to examine signs and evidence of various mezzanines built to accommodate shelving and structures necessary for storing materials in the warehouse. Even more fascinating, however, is the representation of the elevation, which illustrates for the first time how the division between the two liturgical spaces must have initially appeared; it was created by a dividing wall, located under the large arch that still exists, made accessible by the presence of a portal (formerly the location of the altar) flanked by two pilasters. With the end of the Second World War, preceded by the fall of the regime, many barracks and military warehouses were decommissioned; the Benedictine church then became a storage facility for non-war material until around the 1970s. At the end of the 20th century, only the renovations necessary following the collapse of the cornices and the now precarious condition of the roof were carried out. In 2007, the entire complex was decommissioned from government use, and the church and monastery passed into the hands of the State Property Office and the Cassa Depositi e Prestiti, respectively.

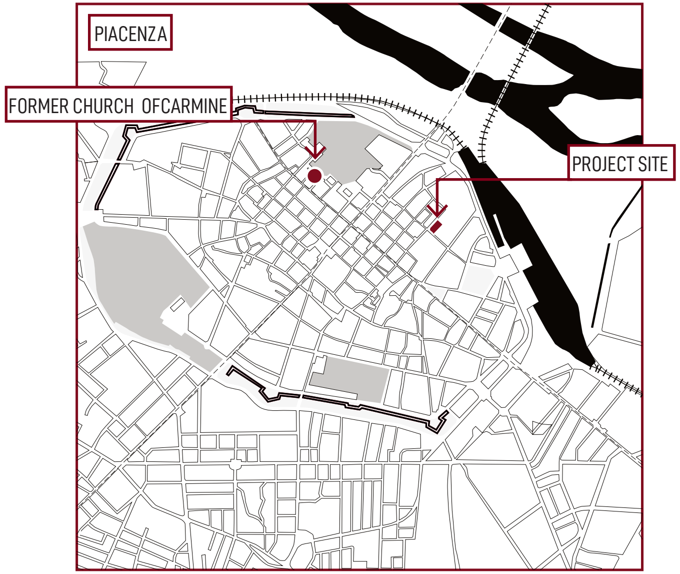
Watercolour depicting the Benedettine church and the square it overlooked
Giovanni Paolo Panini, 1720

01.3 Case studies

FORMER CHURCH OF CARMINE

Located in the historic center of Piacenza, the former church of Carmine is a significant example of Gothic sacred architecture from the second half of the 14th century. Its construction began in 1334 and it was consecrated only in 1352, hosting the Carmelite Order. Following the suppressions during the Napoleonic period, the church underwent gradual abandonment and decommissioning.

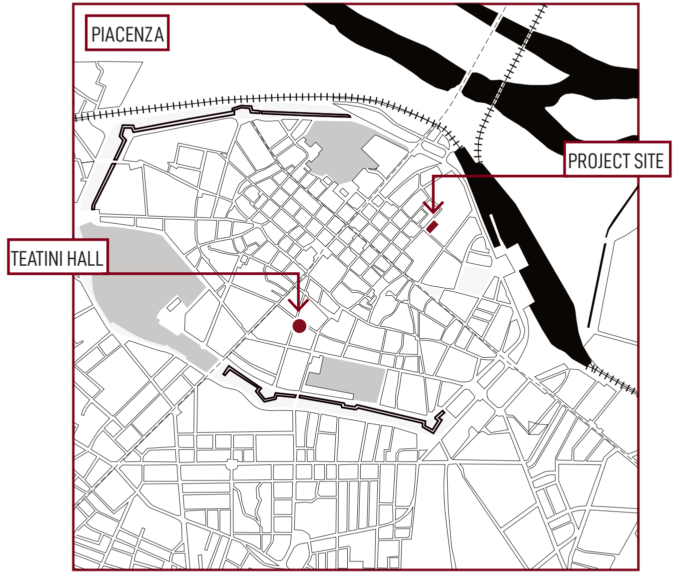
Only in recent years has the church undergone restoration and redevelopment by the Municipality of Piacenza. The work carried out on this historic building has restored a central area to the urban context, transforming it into a multifunctional cultural venue. Today, we can visit the Church of Carmine not only for its architectural beauty but also to take part in events, exhibitions, and concerts. The variety of activities for which the church is used makes it a lively space capable of responding to different social and cultural needs.



TEATINI HALL

The church of San Vincenzo was built by the Theatines, probably beginning in 1595/1600, on land provided by Bishop Burali upon their arrival in Piacenza in 1571. The architect, Pietro Caracciolo, a Theatine from Naples, reused the layout of the churches of Piacenza at the time, taking inspiration from the intense architectural activity of Alessio Tramello, but the design was changed and the new building was extended during construction towards the façade along Via Scalabrini. The building was consecrated on 29 June 1612 and on 23 October 1616 by Monsignor Claudio Rangoni, Bishop of Piacenza. The Theatine Fathers lived in the convent of San Vincenzo until 13 September 1810, when Napoleon ordered the suppression of all religious corporations. With the dissolution of the Theatine order, the church and the adjoining convent were confiscated by the government but, after a long series of vicissitudes, they were auctioned off and passed to the Congregation of the Brothers of the Christian Schools who, after their withdrawal in 1972, sold the properties to the Municipality of Piacenza.

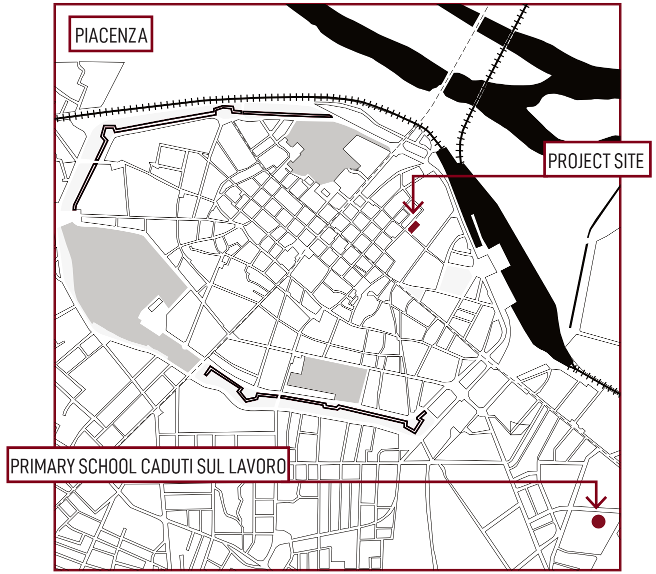
The Teatini Auditorium is the result of meticulous restoration work and the use of the most modern technologies available. The ancient church of San Vincenzo has recovered its original splendour thanks to the restoration of the frescoes and wooden structures - choir, organ case, entrance doors - and the renovation of the former sacristy, now transformed into a dressing room, warehouse, instrument storage room and technical control room.



However, it is only thanks to the use of technology that a place originally dedicated to worship has been converted into a modern, comfortable, well-equipped rehearsal room and auditorium with superb acoustics.

ELEMENTARY SCHOOL "CADUTI SUL LAVORO"

In Italian schools, music education plays a very marginal role and the experience of playing an instrument is reserved for a few children through private initiatives by their families. Based on this premise, some schools in Piacenza have begun to develop music projects that involve not only teaching a musical instrument but also creating a real orchestra. The project we are considering as a case study is called "Orchestra Cinque Quarti" and involves several primary school classes and others, including the "Caduti sul Lavoro" primary school. The project idea developed in a particularly challenging environment: the multi-ethnic and multicultural population (over 50% of children with non-Italian citizenship) with significant social and educational fragility manifested complex needs that highlighted the need to go beyond the usual school logic to involve the professional community in a collective commitment aimed at a significant change in the educational paradigm. The project has therefore grown year after year with the participation of other classes and the introduction of music workshops for all the instruments that make up the orchestra: today, the project involves 400 students, including children and teenagers. However, this significant growth of the orchestra has highlighted the need to find new spaces for teaching musical instruments and, above all, for the students to perform. An inspection carried out at the "Caduti sul lavoro" school showed that, despite the spaces not being suitable for studying music, people are carrying out this project with passion and dedication. For example, the school canteen is transformed every week into an auditorium by teachers and volunteers who have

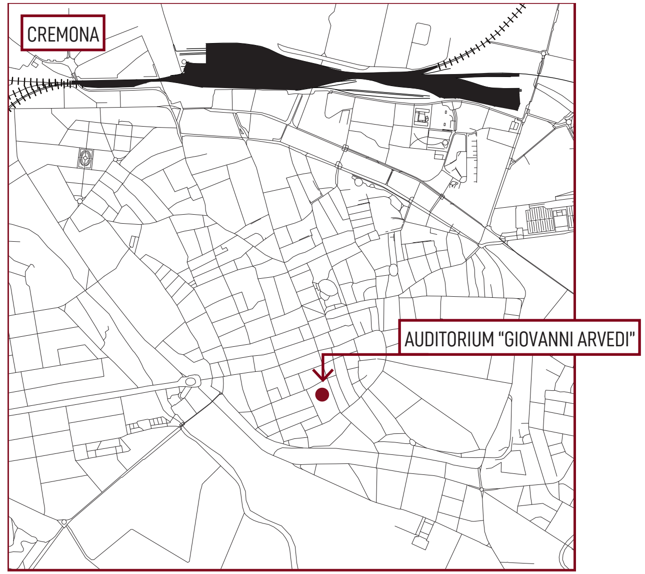


to remove all the furniture, arrange chairs and music stands for all the pupils and then tidy up the room. The acoustics of the spaces do not help the reproduction of musical instruments. Music projects in Piacenza schools are an important social and cultural reality that must be cultivated and developed, which is why it is necessary to find new spaces to adapt and dedicate to them.

AUDITORIUM "GIOVANNI ARVEDI"

The 1930s were a crucial period for Cremona, and not only for violin making. The Fascist regime carried out a process of urban reorganisation that radically changed the layout of the historic centre, adding a series of buildings to the rich architectural heritage of the city, buildings that symbolised a modern culture that was intended to be victorious, strong and stable. Roberto Farinacci (1892-1945) was the first promoter of this project, and the construction of the Palazzo dell'Arte (1942-1946), which currently houses the Violin Museum, represents its final act. The area occupied by the building comes from the demolition in 1924 of the church of Sant'Angelo, one of the oldest in the city, which was initially run by the Benedictines and then by the Observant Franciscans until 1810, and is now commemorated in the name of the square behind the palace. This first demolition was followed by that of the adjoining cloister and the structures attached to it, which were considered unhealthy (1936-1939).

The architectural design for Palazzo dell'Arte is based on the theme of bipolarity between exhibition and music, represented by the intrinsic functions of the Violin Museum and the Auditorium. The Violin Museum is a museum of and for the future, an active, participatory, empathetic museum, born from a powerful idea: to bring together the best of Cremonese violin making under one roof. Overall, the main areas of the Palazzo dell'Arte project are represented by: the Violin Museum, the Temporary Exhibition Pavilion and the Auditorium. The architecture of the Auditorium meets acoustic requirements, taking on a strongly evocative character in the overall context. The exuberance of its plasticity evokes



an expressive and fluid architecture that evolves seamlessly with soft joints, in which everything is connected and echoed in a discursive unity, between calmness and decisive volumetric accents, aspects and intentions aimed at representing the movements of musical composition in three-dimensional form.

CASE STUDY

02 Preliminary data and analysis

02.1 Architectural survey

THE SURVEY

Surveying has always played a central role in architectural design, undergoing significant evolution over time as a direct consequence of technological development. Surveying methods, once based on direct techniques carried out using simple, manual tools, have gradually transformed thanks to the introduction of modern geomatics, which has enabled a considerable reduction in acquisition times and a substantial increase in the accuracy of the data collected. Geomatics is a discipline that deals with the collection, analysis and management of georeferenced metric and spatial informatio, i.e. information referring to a predefined coordinate system through a geocentric approach. Geomatics is a discipline that deals with the collection, analysis and management of georeferenced metric and spatial information, i.e. information referenced to a predefined coordinate system, through an integrated and multidisciplinary approach, with the support of digital technologies. The introduction of advanced instruments, which are increasingly accessible even outside the strictly professional sphere, has made it possible to spread point cloud acquisition technologies to a wider audience, including private users. However, this progress has brought with it new challenges, such as the need to acquire specific skills in the use of complex data processing software, as well as the availability of high-performance hardware capable of supporting its operation. This chapter illustratesin detail the entire surveying process and the techniques used in the specific context of the Benedictine Church.

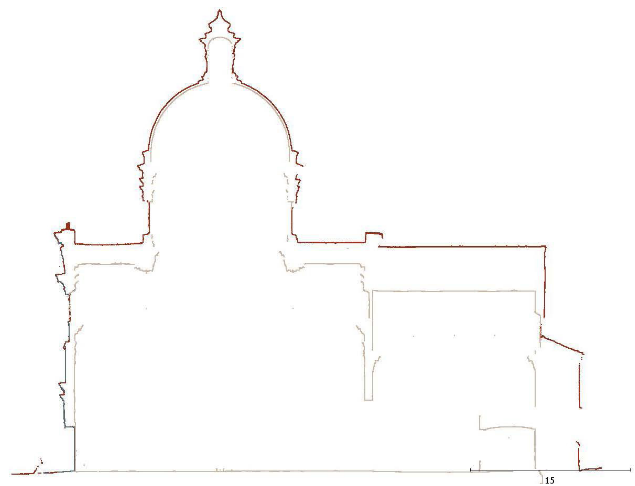
The architectural survey of the Benedictine Church was done by a group of students from the Politecnico di Milano as part of a thesis project totally dedicated to studying the complex's measurements and shape. The work they did involved getting and processing a detailed cloud point of the building, which was a key reference for the later analysis and design stages. The survey activity carried out is a valuable contribution not only for the quality of the data returned, but also for the methodology adopted, which made it possible to obtain an extremely accurate representation of the architecture. This work was based on this solid knowledge base, using the survey as a starting point for the development of an architectural project aimed at enhancing and repurposing the interior space of the church. The importance of having a complete and reliable survey proved crucial in setting up an informed design process that respected the existing geometry and was capable of interacting with the complexity of the historic building.

TASKS PERFORMED

The activities of recording and storing the subsequently processed data took place over just two days, using three different instruments. During the first day, the focus was solely on the external survey of the church, carried out using a laser scanner and photographs taken with a drone, which was georeferenced with great precision after a topographical network measurement. The restitution phase allows the object of the photogrammetric survey to be digitally recreated in three dimensions and consists of several steps of cleaning, resizing and sampling of the point cloud. This phase is fundamental to obtain an accurate, complete and easily usable result for visualisation and analysis. The second day focused on the interior survey of the church, following the same methods used for the exterior. The use of the drone made it possible to acquire images that could not have been obtained in any other way, thus ensuring the completeness of the survey. By cross-referencing the results obtained from laser scanning with those of photogrammetry, every corner of the church was explored. Finally, the localisation of the point cloud in a global reference system was facilitated by the total station.

All the steps taken to process the data mentioned above have made it possible to achieve an integrated result that includes all the information necessary to define the three-dimensional representation of the church. From this configuration, it is also possible to obtain specific two-dimensional representations, useful for analysing the proportions and relationships between the components that characterise the Benedictine Church. In particular, after importing the .las file into the Recap software, it was possible to create detailed, high-quality models of the surveyed structures.

For the Benedettine Church survey project, Recap was used to convert the files from .las format to .rcp format, thus al-lowing the point cloud to be imported into AutoCAD. The ma-nagement of the point cloud on AutoCAD allows for the cre-ation of both 2D and 3D digital drawings as needed. Following careful processing of the cloud on AutoCAD, with particular attention to the management of reference systems, flo-or plans, sections and elevations of the Benedettine Church were produced following the previously created point cloud.



Longitudinal section of the point cloud

EXTERNAL POINT CLOUD OF BENEDETTINE CHURCH,
CLOUD COMPARE

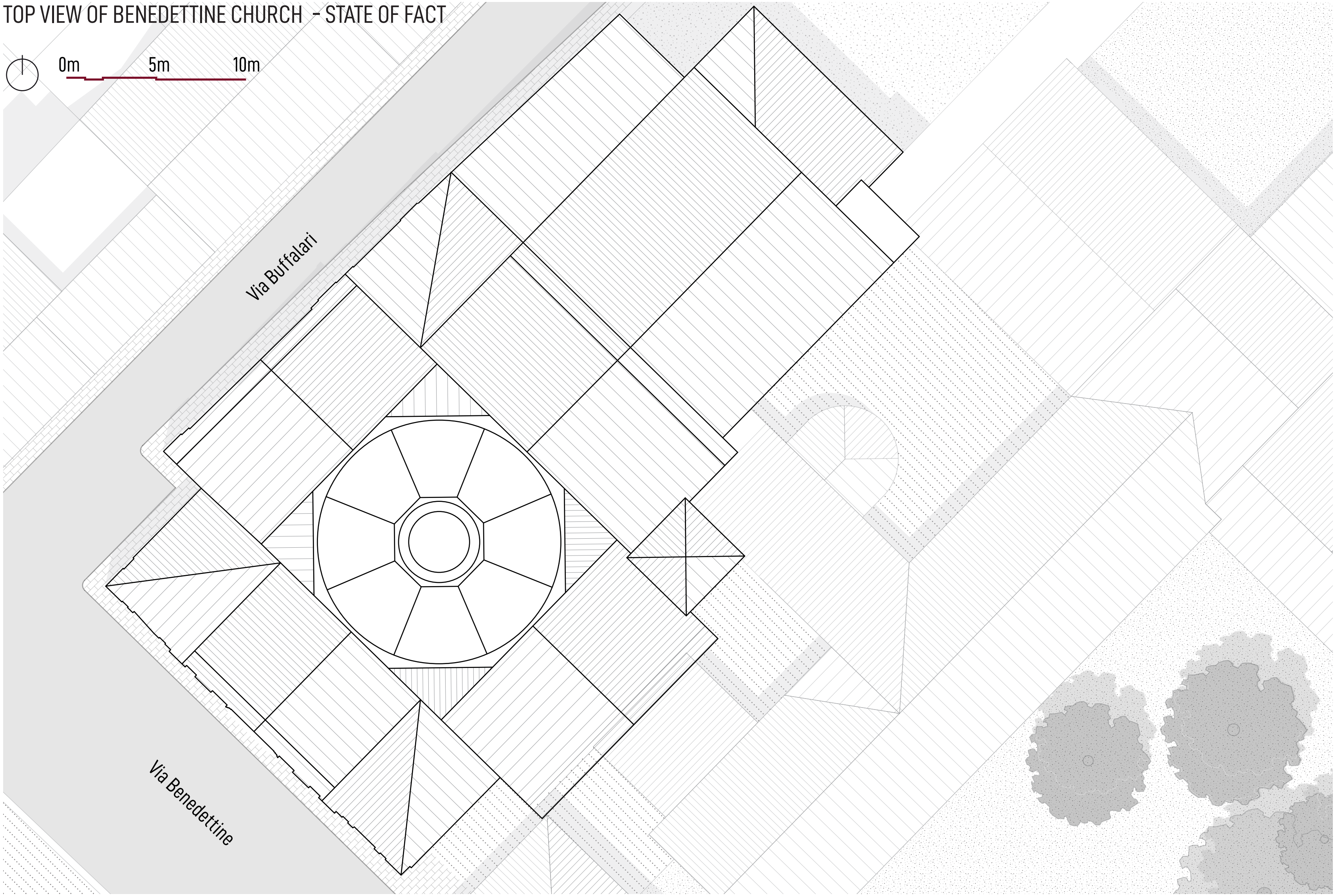
INNER POINT CLOUD OF BENEDETTINE CHURCH, CLOUD COMPARE

POINT CLOUD OF THE LONGITUDINAL SECTION OF THE CHURCH, CLOUD COMPARE

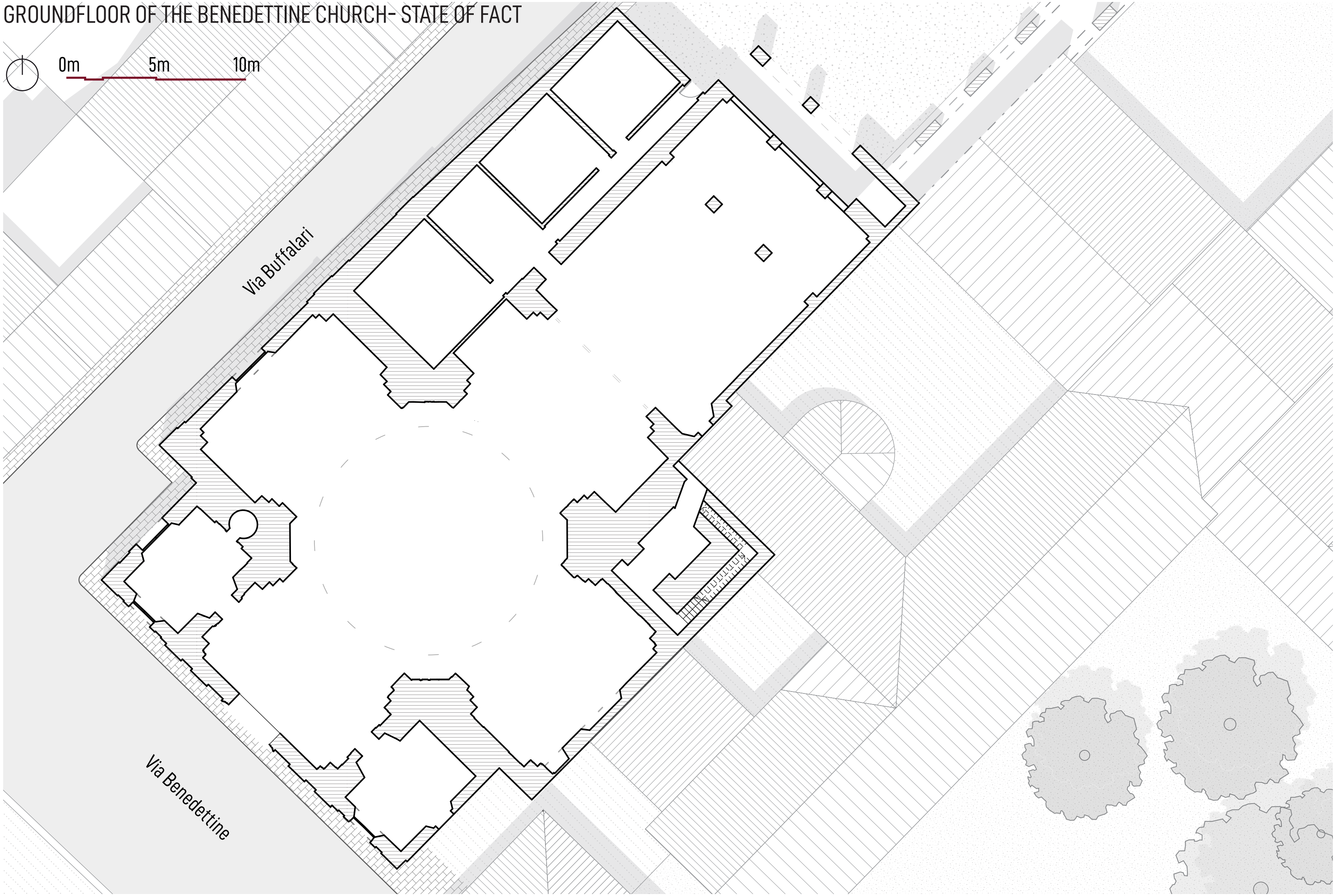
POINT CLOUD OF THE CHURCH FACADE, CLOUD COMPARE

BENEDETTINE CHURCH FACADE, AUTOCAD

TOP VIEW OF BENEDETTINE CHURCH - STATE OF FACT

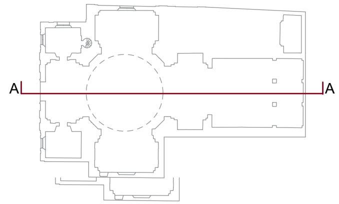


GROUNDFLOOR OF THE BENEDETTINE CHURCH- STATE OF FACT

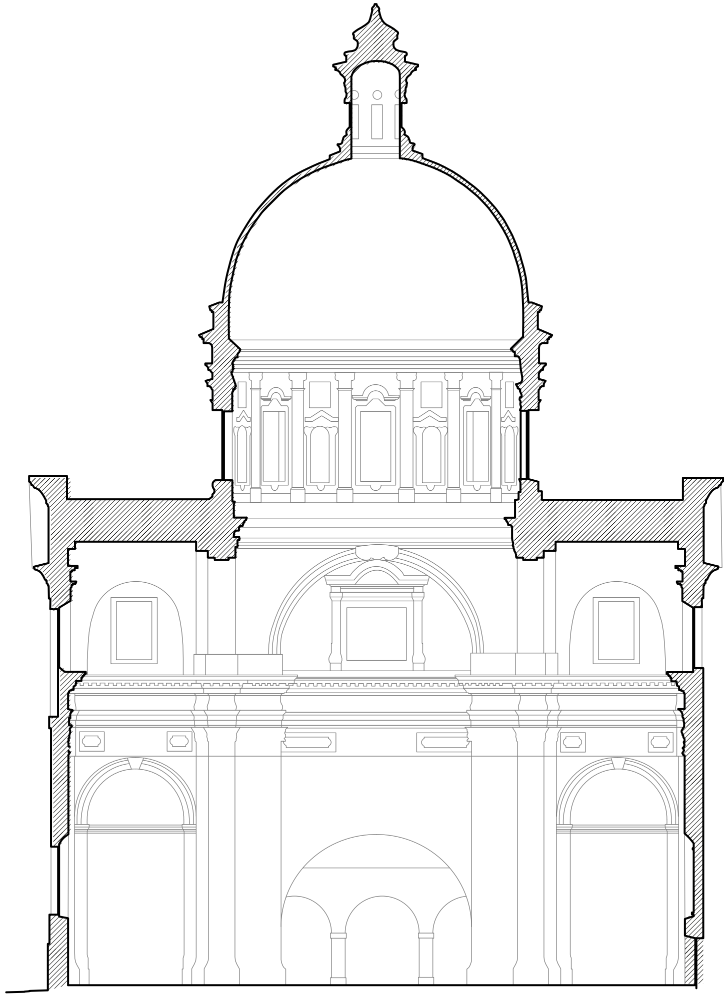


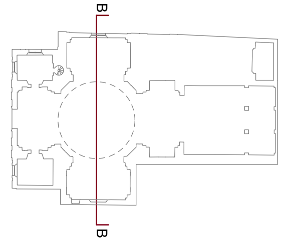
LONGITUDINAL SECTION - STATE OF FACT

0m 5m 10m



CROSS SECTION - STATE OF FACT





PHOTOGRAPHIC SURVEY

VERTICALITY



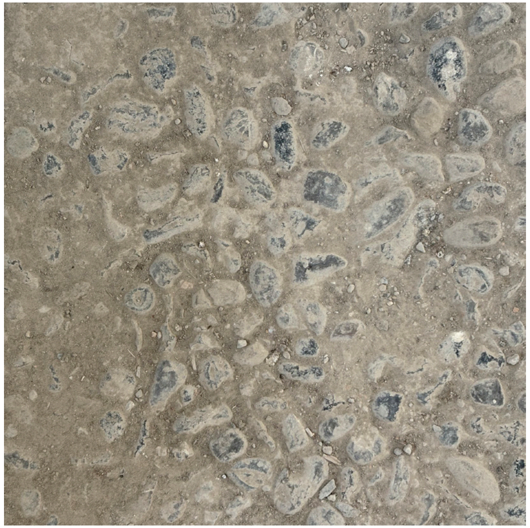


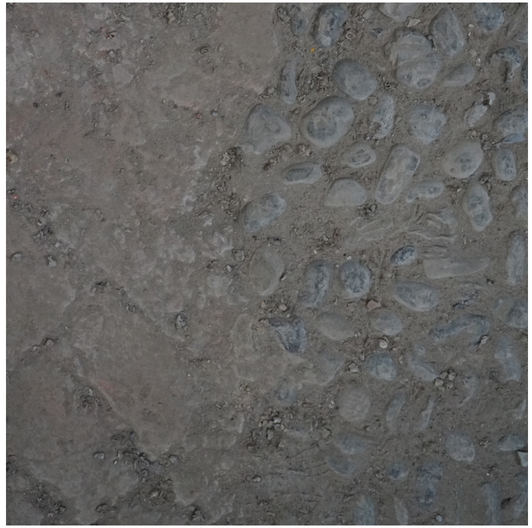

OPENINGS






MATERIALITY





OCCLUSIONS

02.2 Acoustic survey

INTRODUCTION AND SURVEY

In order to guarantee high sound quality within the future auditorium, a preliminary in-depth acoustic analysis of the existing space was necessary. This investigation constitutes the indispensable cognitive basis for guiding the design choices and for ensuring that the renovation work respects both the technical and artistic requirements of musical fruition.
This chapter collects and interprets the results of the acoustic measurements carried out at the former Benedictine Church in Piacenza, a historical building destined to be transformed into a music auditorium.

The main goal of the analysis was to assess the current acoustic characteristics of the environment and compare them with the optimal parameters required for modern concert halls, as indicated by the scientific literature and international guidelines on architectural acoustics.
Understanding the pre-existing acoustic performance is in fact essential in order to plan any corrective and treatment interventions, aimed at guaranteeing clarity, intelligibility of speech and a balanced distribution of sound energy in the space. Only through this preliminary phase is it possible to prepare design strategies capable of combining the building's historical specificity with the functional requirements of a contemporary concert hall.

The acoustic survey was conducted on the morning of 2 December 2024, within the project area, with the intention of documenting the sound conditions of the church before the intervention. The operations were carried out in collaboration with the Image and Sound Processing Lab (ISPL), part of the Department of Electronics, Information and Bioengineering of the Politecnico di Milano, a research centre known for its expertise in the field of applied acoustics and digital signal processing.

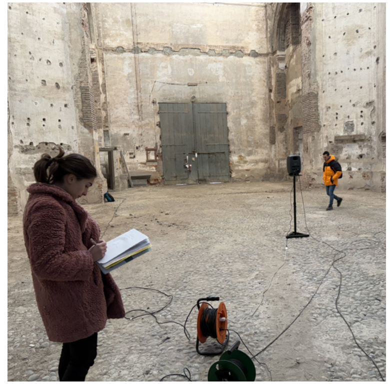
A group of qualified professionals carried out the tests using professional-grade instrumentation and specific analysis software, tools that enabled accurate and reliable data on the acoustic behaviour of the space to be obtained. The entire inspection took place under controlled and optimal conditions, with a total duration of approximately two hours, allowing the collection of a sufficiently large set of information for the subsequent design phase.

Image and Sound Processing Lab

Dipartimento di Elettronica, Informazione e Bioingegneria

Politecnico di Milano





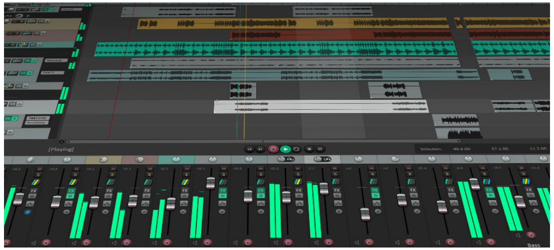
EQUIPMENT AND METHODOLOGY

The acoustic measurements were conducted following an accurate positioning protocol of the sound source and microphone, with the aim of reliably detecting the physical and perceptual characteristics of the environment.
Since the area had no direct connection to the electrical network, it was necessary to use a portable power generator, positioned outside the test space. This choice made it possible to avoid possible interference from the mechanical noise produced by the device, thus guaranteeing optimal detection conditions.
The instrumentation used included a sound source (Genelec 8040A loudspeaker) **[1]**, a measurement condenser microphone (Beyerdynamic MM1) **[2]** and a computer equipped with data acquisition and processing software (Reaper) **[3]**, all connected via an external sound card (Focusrite Scarlett) **[4]** .
The combination of these instruments, chosen for their reliability and widespread use in the professional sphere, made it possible to obtain precise data collection in compliance with acoustic measurement standards.
The survey was carried out by positioning the source and microphones at different points in the room, in order to provide as complete a representation as possible of the acoustic conditions of the space. Specifically, the microphones were placed in three strategic positions, selected to represent different listening areas and to ensure balanced spatial coverage. The sound source was positioned approximately 1.4 metres above the floor and directed towards the microphones, which were fixed at a height of 1.2 metres, corresponding to the average height of a seated listener.

The acquisition of reliable data was made possible by these configurations, which allowed a detailed analysis of the acoustic characteristics of the environment. A sinusoidal sweep signal, capable of covering the entire frequency spectrum perceptible to the human ear, was used for the measurements. This type of signal allows precise responses at all frequencies, being particularly useful in the evaluation of parameters such as reverberation time, clarity and intelligibility of sound.
The measurements were carried out in the absence of an audience and without significant furniture, so as to operate in neutral environmental conditions. Despite the proximity to a city street without adequate sound insulation, traffic noise did not influence the measurements: the tests were scheduled at quiet times with targeted waits for vehicles to pass. This ensured the reliability and consistency of the results collected.
The data obtained, analysed in detail in the following section, forms the basis for the comparative evaluation with the optimal parameters required in a modern auditorium.

[1]

[2]



[3]

[4]

Acoustic Source
Microphone
Power Generator Source
S1
M right
S2
M centre
M left

OBTAINED RESULTS

The data collected made it possible to analyse various acoustic parameters that are fundamental for understanding the sound characteristics of the space. Considering that the structure under examination was originally intended for sacred music, the results obtained turned out to be in line with the expected expectations, confirming the hypotheses formulated in the preliminary analysis phase.

Reverberation Time (RT):

Reverberation time (RT or RT60) is the time required for the sound level in a room to decrease by 60 dB after the sound source has been turned off (ISO 3382-1:2009).

Practically, reverberation time indicates how long a sound continues to "resonate" in a space after the source stopped.

The initial decay time (EDT):

Early Decay Time (EDT) is the time required for the sound level in a room to decay by 10 dB after the arrival of the direct sound, multiplied by six to estimate an equivalent decay of 60 dB (ISO 3382-1:2009).

Generally considered a better index of acoustic clarity than RT60 because it better reflects the way the human ear perceives an environment. If the EDT is short, the sound will be clear and defined. If, on the other hand, the EDT is long, the sound will be more welcoming but less intelligible.

	EDT [s]	T30 [s]
S1-M centre	4.6093	5.4089
S1-M right	4.5477	5.5782
S1-M left	4.5527	5.5839
S2-M centre	4.2524	5.4871
S2-M right	4.9773	5.8384
S2-M left	4.3367	5.7569

Optimal RT values in concert halls: between 1.8 and 2.2 seconds in the middle frequencies.

Clarity Index (C80):

Logarithmic ratio between the sound energy within the first 80 ms and the next.

Formula:

$$C_{80} = 10 \cdot \log_{10} \left(\int_0^{80ms} p^2(t)\, dt \; / \; \int_{80ms}^{\infty} p^2(t)\, dt \right)$$

Where:

- p(t) is the impulse response of the room
- The numerator represents the energy arriving within the first 80 ms
- The denominator represents the energy arriving after 80 ms

	C80 [dB]
S1-Mcentre	3.2677
S1-Mright	1.7824
S1-Mleft	2.4114
S2-Mcentre	4.0254
S2-Mright	- 1.3496
S2-Mleft	1.9037

Optimal values in concert halls: between -4 dB and +1 dB

Bass Ratio (BR):

Bass Ratio (BR) measures the balance between Low and High Frequency Reverberation Time, indicating acoustic "warmth".

Formula:

$$BR = (RT_{125} + RT_{250}) \; / \; (RT_{500} + RT_{1000})$$

Where:

- RT_{125} = reverberation time at 125 Hz
- RT_{250} = reverberation time at 250 Hz
- RT_{500} = reverberation time at 500 Hz
- RT_{1000} = reverberation time at 1000 Hz

	BR
S1-Mcentre	1.2427
S1-Mright	1.2657
S1-Mleft	1.3466
S2-Mcentre	1.3117
S2-Mright	1.3287
S2-Mleft	1.3364

Optimal values in concert halls: between 1.1 and 1.8.

Reverberation Time – Frequency Information

Reverberation time is defined as the time it requires for a sound to attenuate by 60 dB after the sound source has stopped producing it. This parameter is one of the main indicators for assessing the acoustic quality of an enclosed space, as it directly influences speech clarity and musical performance.

Formula:

$$RT_{60} = 0.161 \cdot V / A$$

Where:

- V = volume of the room [m^3]
- A = equivalent absorption area [m^2], given by the sum of (surface × absorption coefficient)

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
S1-M centre	5.9855	5.6725	5.4117	4.3716	3.3096	1.7136
S1-M right	6.0389	5.5097	5.2749	4.2694	3.2569	1.7831
S1-M left	6.1669	5.7712	5.2354	4.2429	3.1642	1.6677
S2-M centre	6.0803	5.6841	5.3639	4.2076	3.0812	1.7048
S2-M right	5.9892	5.5728	5.2033	4.2413	3.1540	1.6840
S2-M left	6.1619	5.7047	5.2045	4.4138	3.3720	1.8552

Optimal values in concert halls: between 1.8 and 2.2 seconds in the middle frequencies.

Central Time:

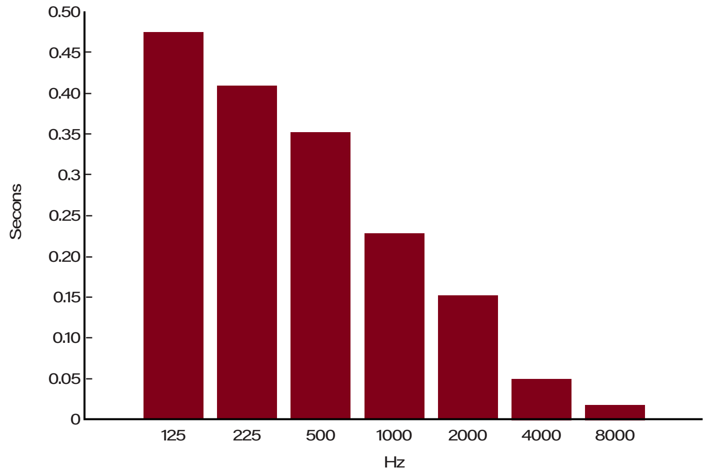
Central Time (CT) measures the time value of the centre of mass of the impulse response. Lower values indicate greater clarity of sound.

Formula:

$$CT = \left(\int_0^{\infty} t \cdot p^2(t)\, dt \right) \, / \, \left(\int_0^{\infty} p^2(t)\, dt \right)$$

Where:

- $p(t)$ is the impulse response of the room
- The numerator is the energy weighted by time
- The denominator is the total energy



Optimal values in concert halls: between 20-40 ms.

Definition Index (D50):

The Definition Index represents the percentage of sound energy arriving in the first 50 milliseconds after the direct sound. Similar to the Clarity Index, it is also used to assess the clarity and definition of sound in a space.

Formula:

$$D_{50} = \left(\int_0^{50\,ms} p^2(t)\, dt \, / \, \int_0^{\infty} p^2(t)\, dt \right) \times 100\%$$

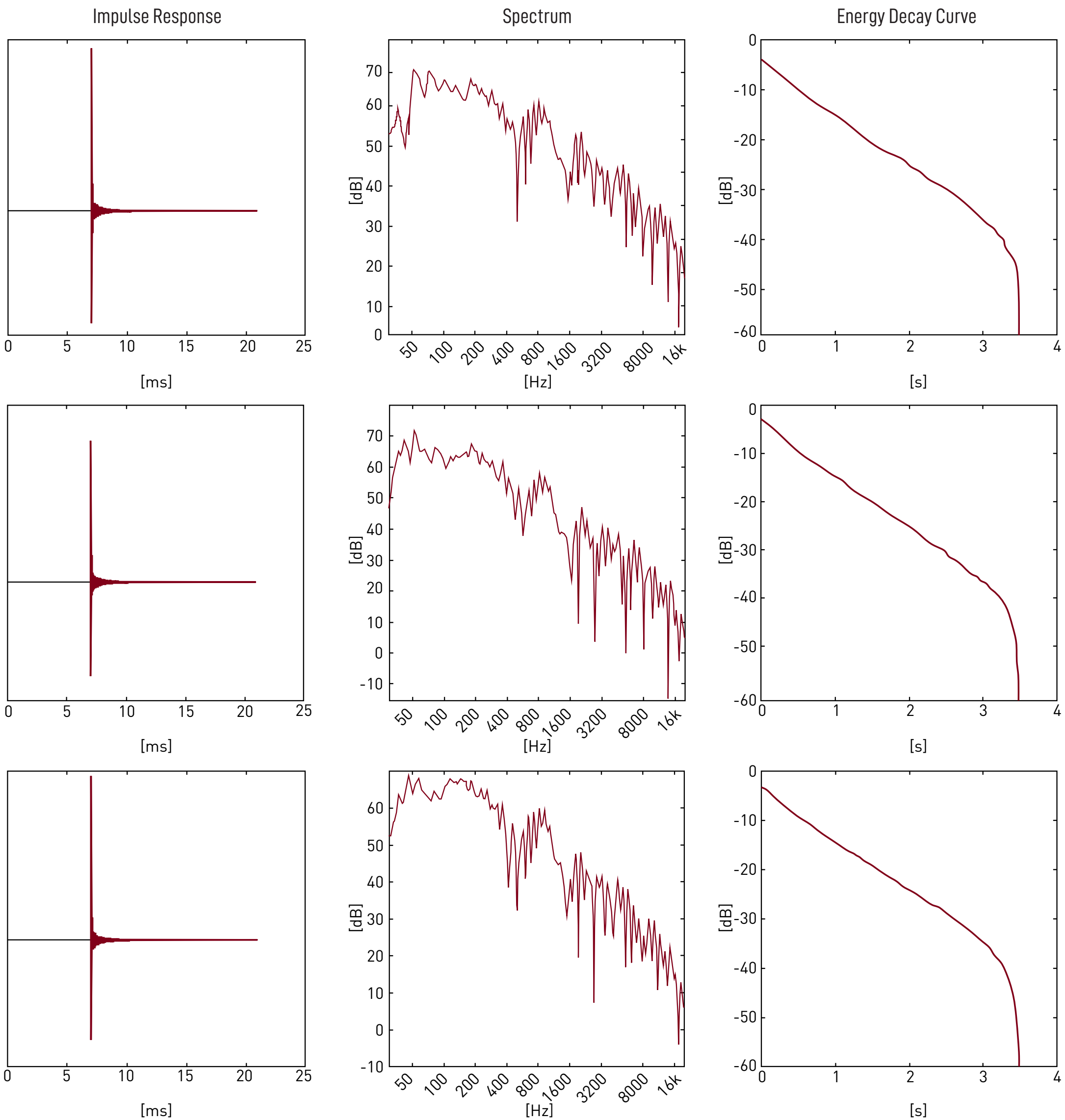
Where:

- $p(t)$ is the impulse response of the room
- The numerator represents the energy arriving within the first 50 ms
- The denominator is the total energy

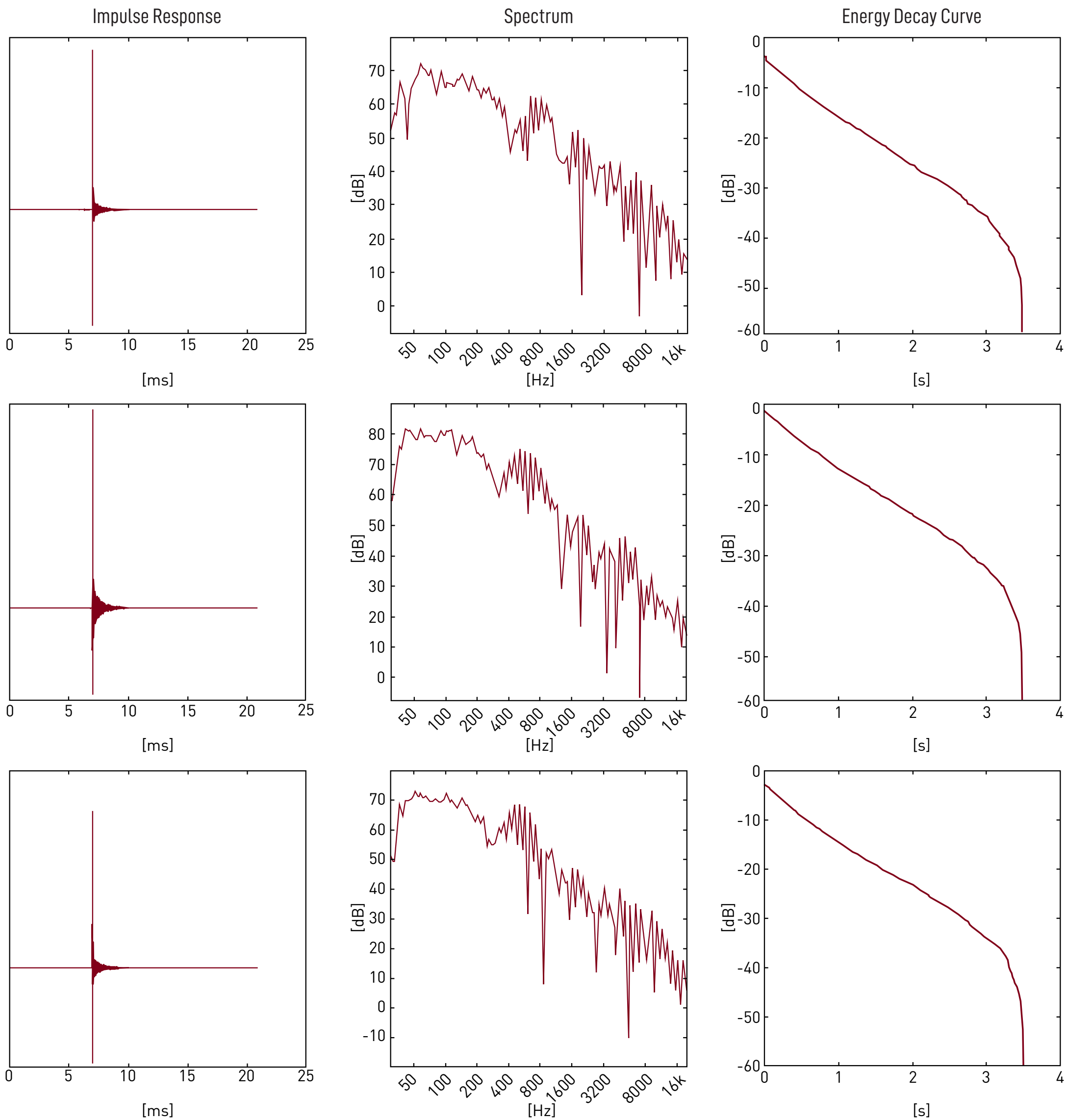
	D50 [%]
S1-M centre	66.66
S1-M right	54.19
S1-M left	61.27
S2-M centre	69.23
S2-M right	35.50
S2-M left	54.99

Optimal values in concert halls: 50-70%.

Impulse analysis:
Source position 1



Impulse analysis:
Source position 2



CONCLUSIONS

The data collected during the morning analysis was consistent with the environmental context in which it was collected.
Despite being a space designed for worship and not for concerts or exhibitions, the former church presents a balanced sound energy decay.

As expected, a high reverberation time was detected, particularly in the low frequencies. This critical aspect will have to be carefully addressed in the final design phase, implementing targeted solutions and designing spaces that, through the use of specific materials, shapes and designs, allow for optimal acoustics.

The acoustic survey results were consistent with the environmental and architectural context in which it was carried out. Although the building was originally designed as a place of worship rather than a concert or exhibition hall, the former church revealed a relatively balanced sound energy decay, which is an encouraging starting point for its conversion into a concert hall. As expected, measurements revealed a long reverberation time, particularly at low frequencies, a typical characteristic of large spaces with reflective surfaces. This critical aspect will have to be addressed with particular attention in the final design phase.
Targeted solutions will need to be implemented, using specific materials, geometric shapes and architectural design strategies to optimise the acoustic response of the room.

Preliminary assessments suggest that, with appropriate acoustic treatment, the space could reach values compatible with the ideal ranges for an auditorium intended for chamber or choral music. In this sense, the project is not limited to correcting acoustic deficiencies, but aims to create a distinctive listening environment that integrates the historical identity of the former church with the functional requirements of a modern concert hall.

The ultimate goal is to offer both musicians and listeners an engaging and unique sound experience, different from that typically offered by traditional concert halls, thus enhancing both the artistic and perceptual dimensions of musical performance.

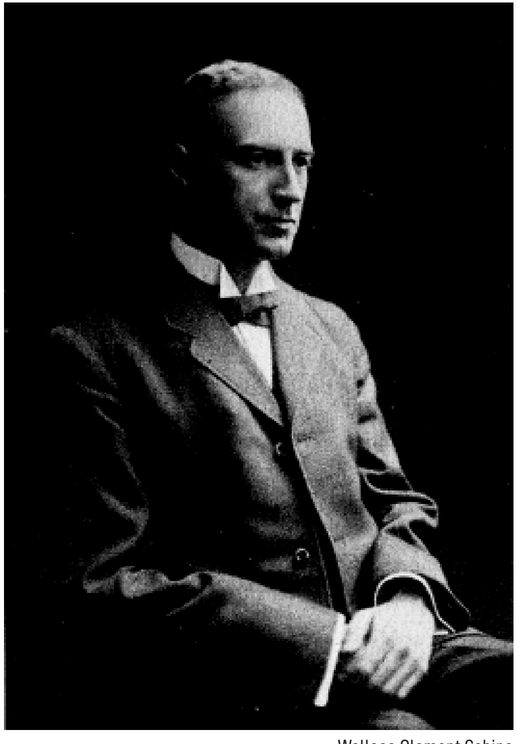
From a design perspective, the aim will be to reduce the reverberation time of the church to values compatible with its function as an auditorium, bringing it closer to the optimal range indicated by international literature for concert halls, between 1.8 and 2.2 seconds in the middle frequencies.

02.3 Sabine calculation - State of fact

SABINE

Wallace Clement Sabine (1868–1919) was an American physicist who, almost by accident, found himself starting a revolution in the field of building acoustics. At the time, acoustic problems in buildings were often dealt with empirically, without a structured scientific method. Sabine, on the other hand, had the insight and patience to turn those fragmentary observations into an organic discipline, resulting in what we know today as modern applied acoustics. The decisive moment came when the managers of the Fogg Lecture Hall at Harvard University's Fogg Art Museum entrusted him with the task of solving the hall's acoustic problems. Sabine immersed himself in a long series of experiments: he often worked at night, armed only with stopwatches, portable organs and stacks of pillows to be moved to alter the sound absorption. With tenacity, he recorded the time it took for a sound to die out, trying to find a law that related the size of the room, the materials used and the persistence of the sound. From this almost obsessive work came the formula that still bears his name today: the famous equation for calculating the reverberation time (T60) of a closed hall.

But Sabine's contribution was not only technical. With his studies, he also inaugurated a new way of conceiving architecture: the design of spaces could no longer neglect sound. In fact, he introduced the concept of acoustically "responsible" architecture, emphasising how aesthetics, function and sound quality were inseparable elements in the construction of places for music, speech or worship. This is Sabine's true legacy: not just a formula, but an approach that continues to guide architects and acoustic engineers today.



Wallace Clement Sabine

SABINE CALCULATION

As already mentioned, reverberation time, commonly referred to by the acronym T60, is one of the key parameters for assessing the acoustic quality of an enclosed space and is expressed in seconds. In simple terms, it describes the time it takes for a sound to decrease by 60 decibels after the sound source has been interrupted.

For the purpose of clarity, the phenomenon can be compared to the more familiar concepts of echo and resonance: reverberation is the "residual presence of sound" that continues to be perceived within a room after the original sound has died down.

When T60 is excessively long, as in the case of highly resonant rooms characterised by large volumes and reflective surfaces, sounds tend to overlap and intertwine, creating an acoustic confusion effect. Conversely, too short a reverberation time gives the opposite sensation: sound appears dry, unnatural and sometimes muffled, reducing clarity and depth of perception.
For this reason, every room has an ideal reverberation time, which depends strictly on its intended use. A lecture hall, for example, requires much lower values than a symphonic auditorium, while spaces intended for choral singing are in an intermediate range, capable of guaranteeing both intelligibility and richness of sound.
The operational method for acoustic correction of a room with excessive T60 consists of three main steps:

1. Calculate the current reverberation time through acoustic measurements;

2. Define the optimal reverberation time based on the intended function of the space;

3. Determine the type and amount of materials or design solutions to be introduced to achieve the desired result.

This approach, based on the formula developed by Sabine, is still the reference tool in acoustic design today, due to its ability to provide a simple yet highly effective model for predicting and optimising the acoustic behaviour of indoor spaces.

After conducting an acoustic survey and collecting reliable data through the use of professional instrumentation, it was possible to compare the experimental measurements with the simulations elaborated in the design phase by applying Sabine's formula.

This equation is still the most widely used tool for estimating the reverberation time (T60) of a closed room:

$$T60 = 0.161 * (V/A)$$

Where:

- (T60) è espresso in secondi.
- (V) indica il volume del locale analizzato in m3.
- (A) è l'area di assorbimento acustico equivalente espressa in m2.

The equivalent sound absorption area (A) is calculated using the following formula:

$$A = \sum (\alpha i * si)$$

Where:

- (si) is the i-th surface area expressed in m2.
- (αi) is the sound absorption coefficient of the same surface.

SABINE CALCULATION - STATE OF FACT

Further to the survey of the interior of the Benedictine Church, the next step was to apply Sabine's calculation using the data collected in situ as a reference.

Firstly, the volumes of the church were determined by considering the building as it is, without internal subdivisions, as a single, continuous environment. The volumetric analysis revealed a considerable internal volume, due to the presence of very high ceilings: this characteristic, as is well known, is one of the main causes of prolonged reverberation times.

The second step involved the reconnaissance of the materials present inside the church. The surface areas in square metres of the main architectural components were then calculated and the relative sound absorption coefficient was attributed to each of them.

In a third step, the values obtained were compared with professional technical databases and validated through the advice of an engineer specialised in acoustic construction, the co-author of this thesis.

This comparison made it possible to proceed with a Sabine calculation based on realistic and reliable parameters.
The demonstration conducted at this phase was necessary in order to set the calculation model on concrete and representative data.

This solid basis will be the starting point for the subsequent simulations, which will concern the acoustic design with the inclusion of new materials, coatings and technological solutions. The aim is to significantly reduce the reverberation time and improve the overall acoustics of the building, making it suitable for its future use as an auditorium for orchestra and choral music.

Volumetric computation results

- Vtot = 11.200 m^3

Surfaces calculation results:

Surface	m^2
Wooden door	20
Cobblestone floor	687
Glass	50
Historic plastered masonry	3600

Sound absorption coefficient per octave band:

Surfaces	125 Hz	250 Hz	500 Hz
Wood door	0,15	0,11	0,1
Cobblestone floor	0,02	0,02	0,03
Glass	0,18	0,06	0,04
Historic plastered masonry	0,08	0,09	0,12

Surfaces	1000 Hz	2000 Hz	4000 Hz
Wood door	0,09	0,1	0,11
Cobblestone floor	0,03	0,03	0,04
Glass	0,03	0,02	0,02
Historic plastered masonry	0,16	0,22	0,24

RESULTS

To estimate the acoustics of the church, we combined the actual survey with a theoretical calculation of reverberation time using Sabine's formula. This comparison was useful to understand how representative the mathematical model was of the actual conditions in the building.

As can clearly be seen from the table, the values measured during the survey on 2 December 2024 are quite close to those calculated with Sabine: the discrepancies, especially in the mid to low frequencies, are within the order of size that one would expect when passing from a theoretical model to a real situation. In other words, the survey confirmed that the theoretical approach describes the acoustic behaviour of the church well.

This coherence between theory and practice is crucial: it allows us to use Sabine's model not only as a verification tool, but also as a working basis for simulating the efficiency of the various interventions. Having a trustworthy model means that we can predict how the reverberation time will vary with the insertion of sound-absorbing materials or with focused architectural changes, reducing the margin of the uncertainty and making the design process towards an optimal acoustic solution more reliable.

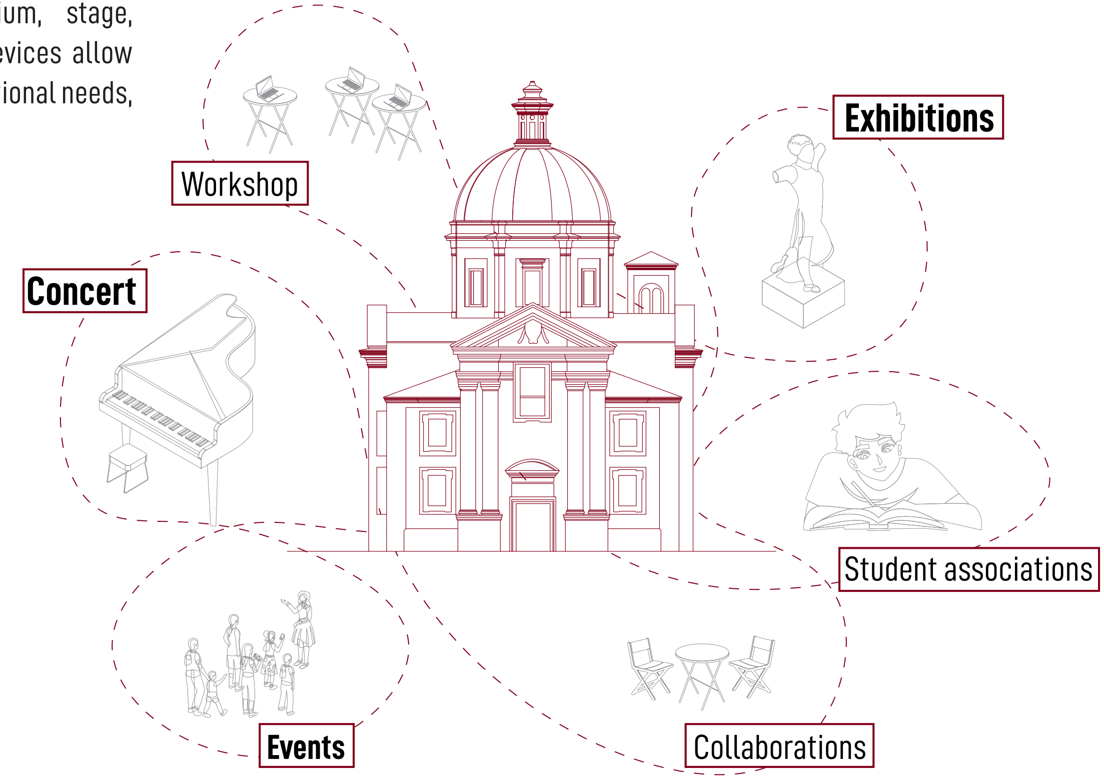
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
T60 - State of fact	**5,75**	**5,26**	**3,95**	**3,01**	**2,21**	**2,02**
T60 acoustic survey	6,07	5,65	5,28	4,29	3,22	1,74

03. Architectural design

03.1 Concepts and strategies

FUNCTIONAL DIAGRAM

The idea behind the project is to give back a disused building to the community, transforming it into a meeting place for cultural, artistic and musical events. The church thus becomes a centre capable of hosting festivals, concerts, temporary exhibitions, debates and presentations. The new space has been designed to be flexible: the different configurations of the auditorium, stage, exhibition panels and reversible acoustic devices allow the venue to be adapted to different organisational needs, while preserving the historic surfaces.



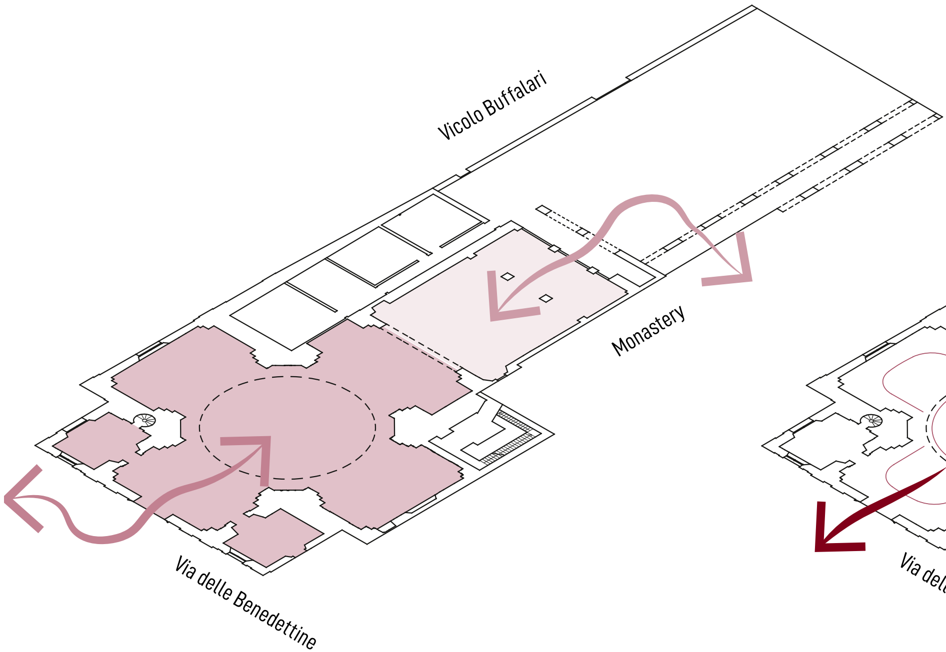
ACCESSIBILITY

Original configuration of the church

Originally, the building was designed to function as two separate liturgical spaces, intended respectively for the faithful and for cloistered nuns.

New design

The new project reverses the orientation of the main entrance, increasing the public permeability of the complex. The main entrance will be on Vicolo Buffalari, with a path through the cloister, which becomes the new reception area.



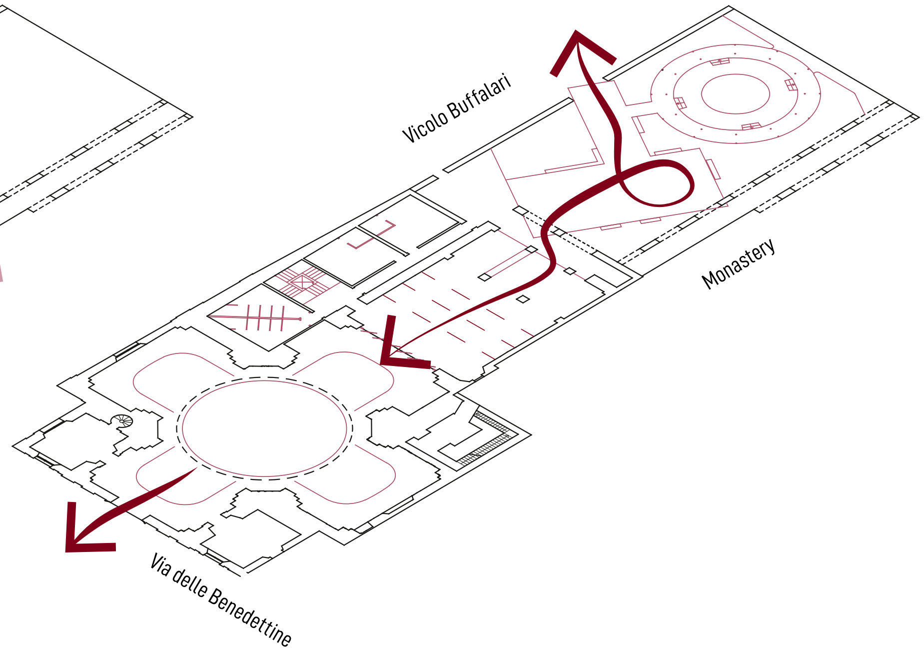
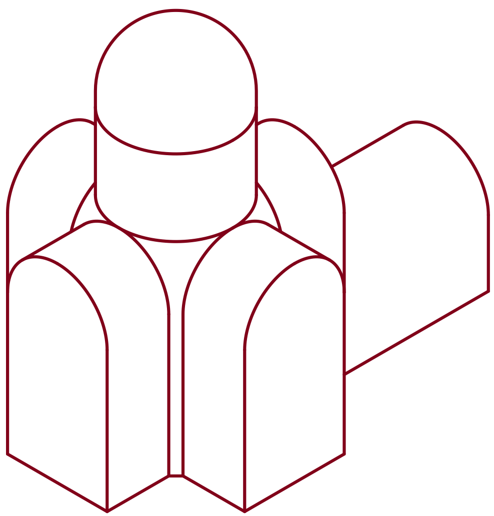


DIAGRAM OF VOLUMES

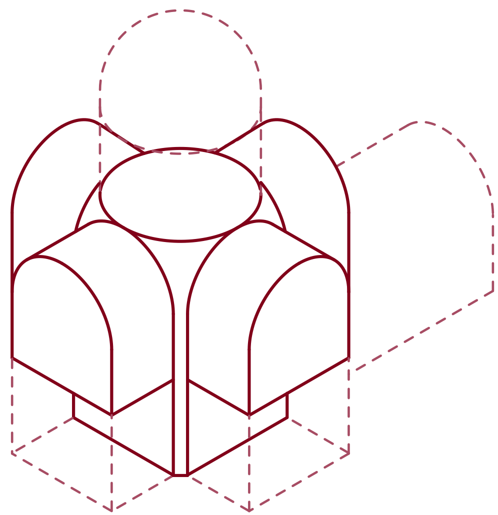
Exhibition

In this configuration, the entire volume of the church remains linked, allowing the space to be configured freely and adapted to different exhibition functions or temporary events. The original spatiality is preserved and valorised as a multifunctional ambience.



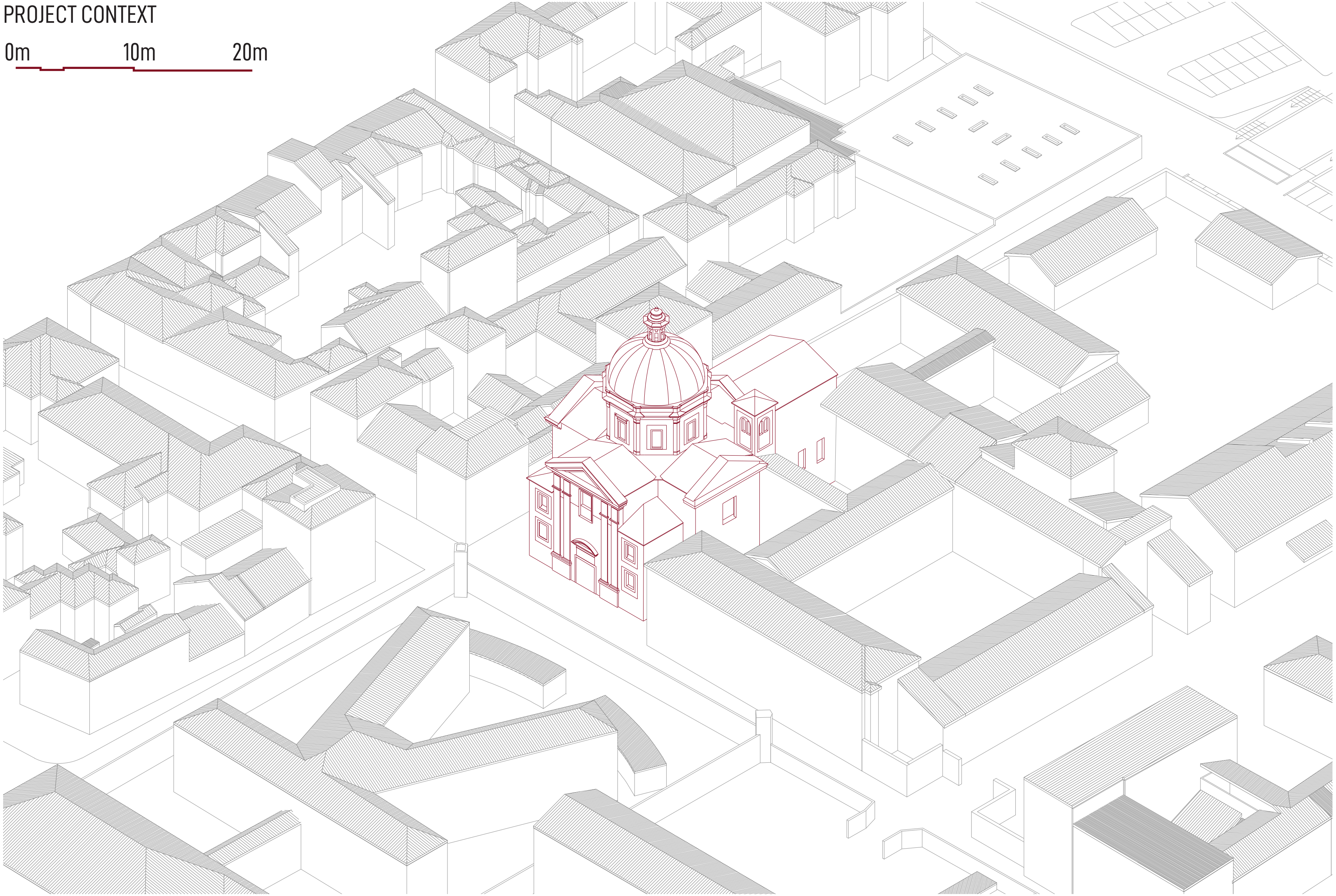
Auditorium

In this configuration, the volumetric subtraction elements reduce the overall volume and ensure insulation from the external environment.
As a result, the acoustic response of the hall is optimised, ensuring clarity and sound control, which are essential qualities for the functioning of an auditorium.

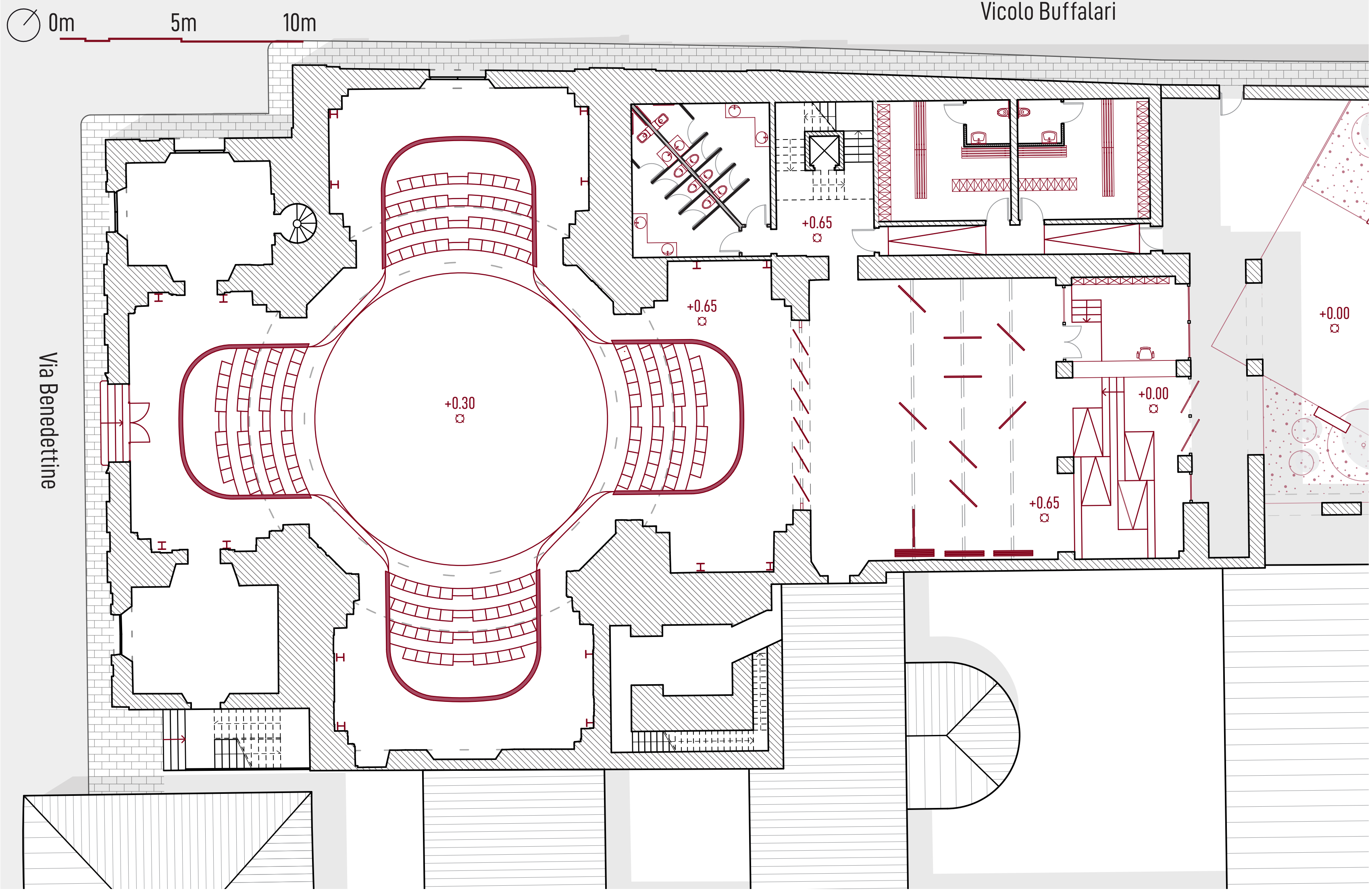


03.2 Technical drawings and views

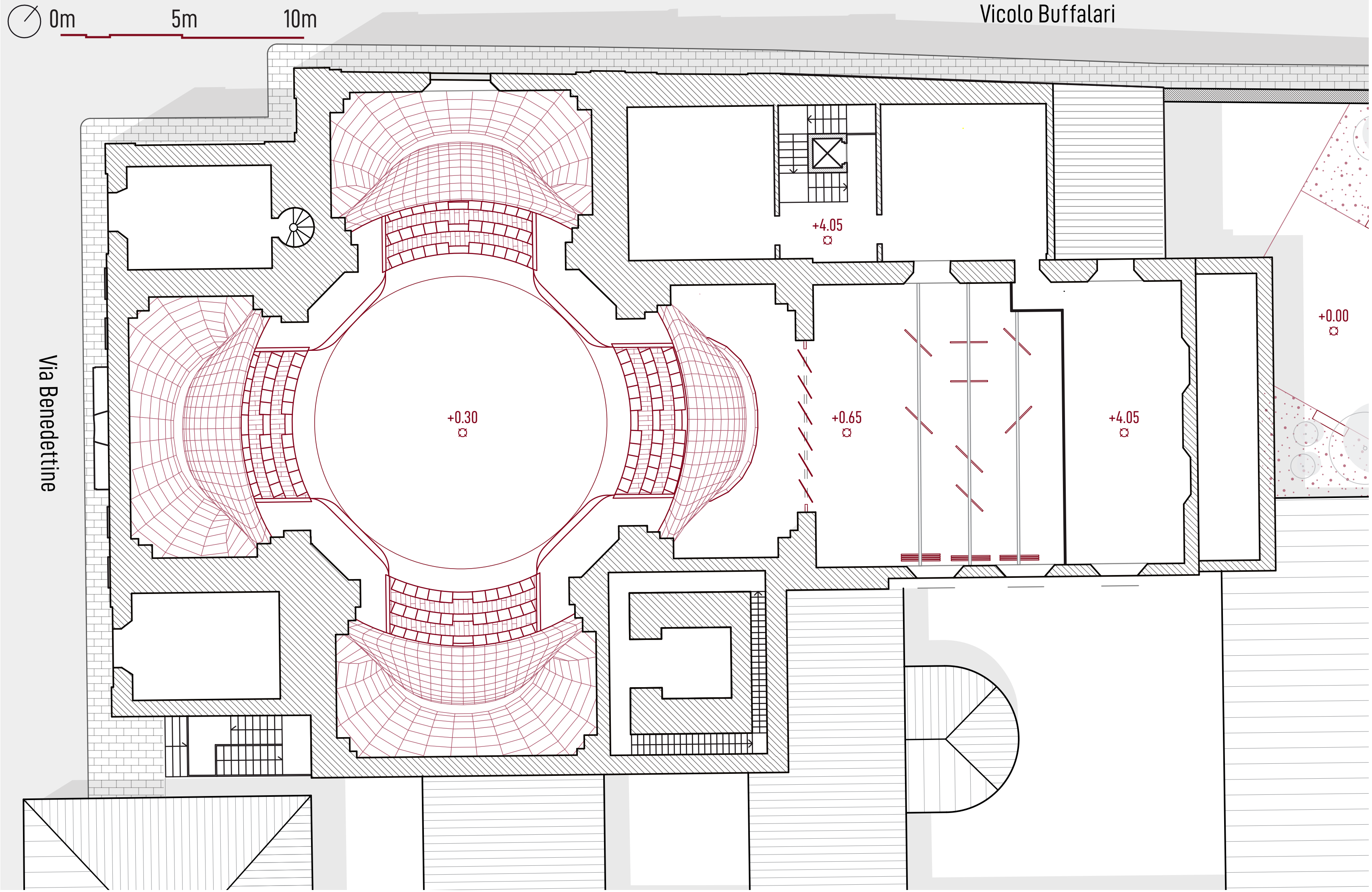
PROJECT CONTEXT



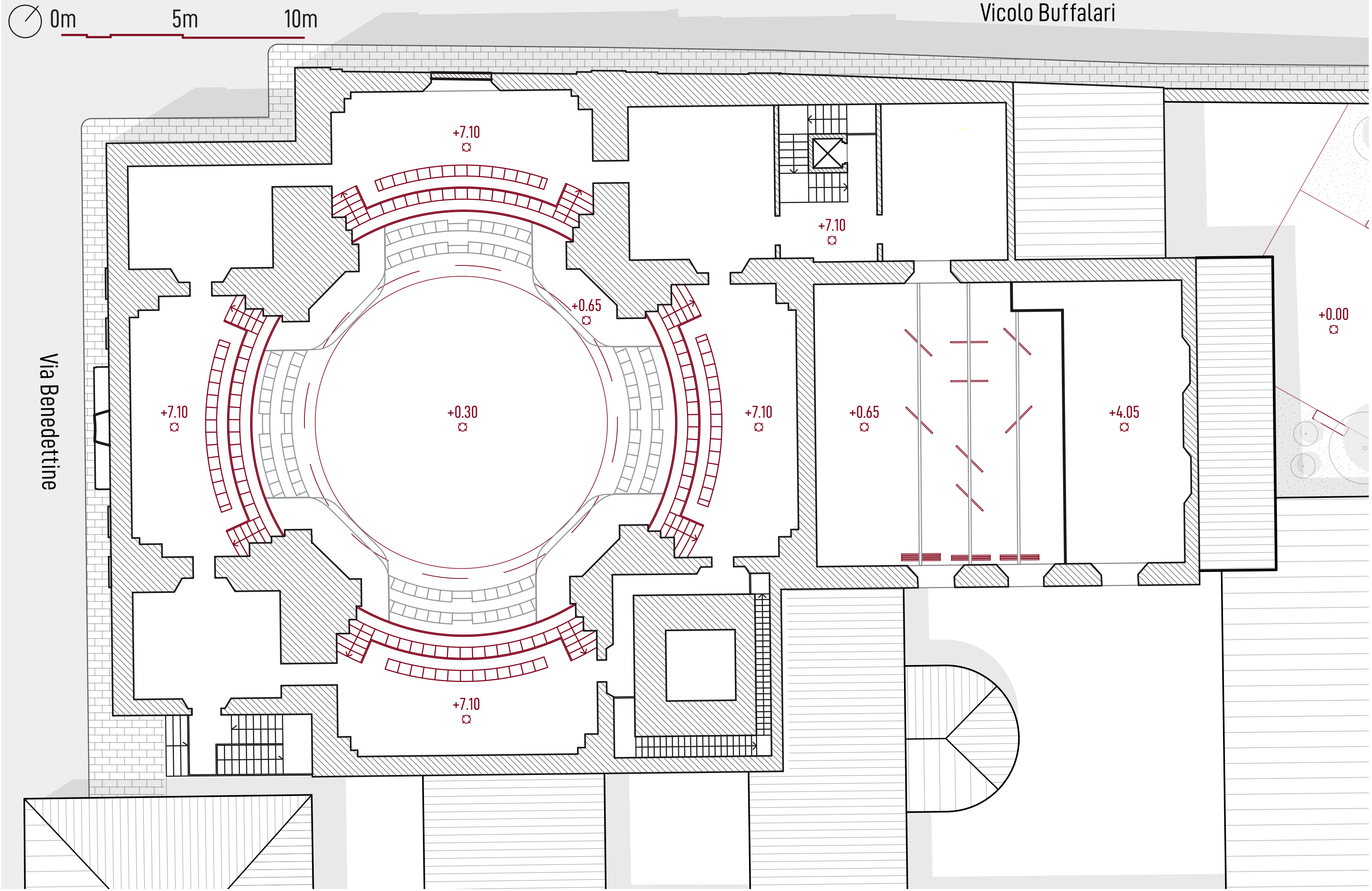
GROUND FLOOR PLAN



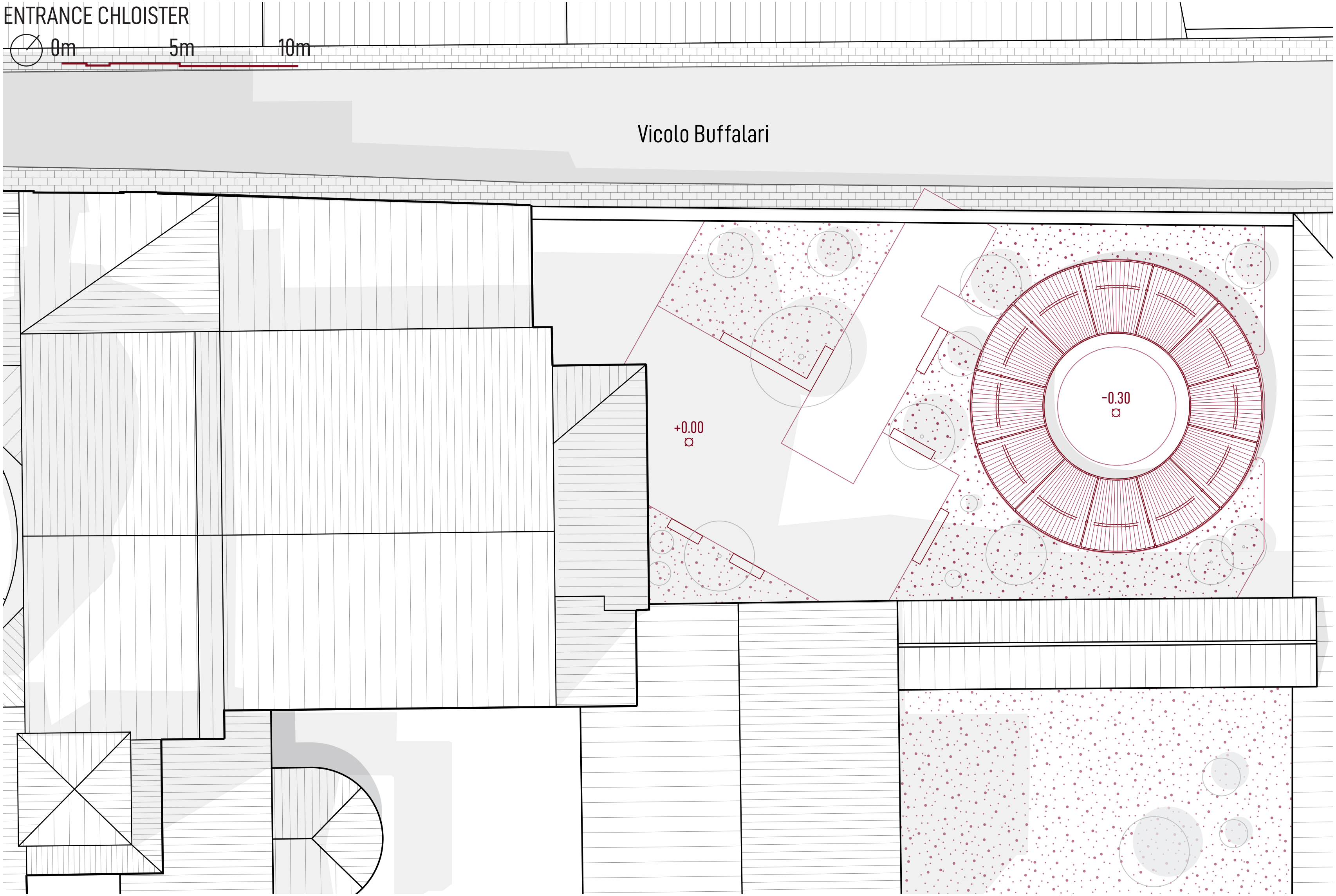
FIRST FLOOR PLAN



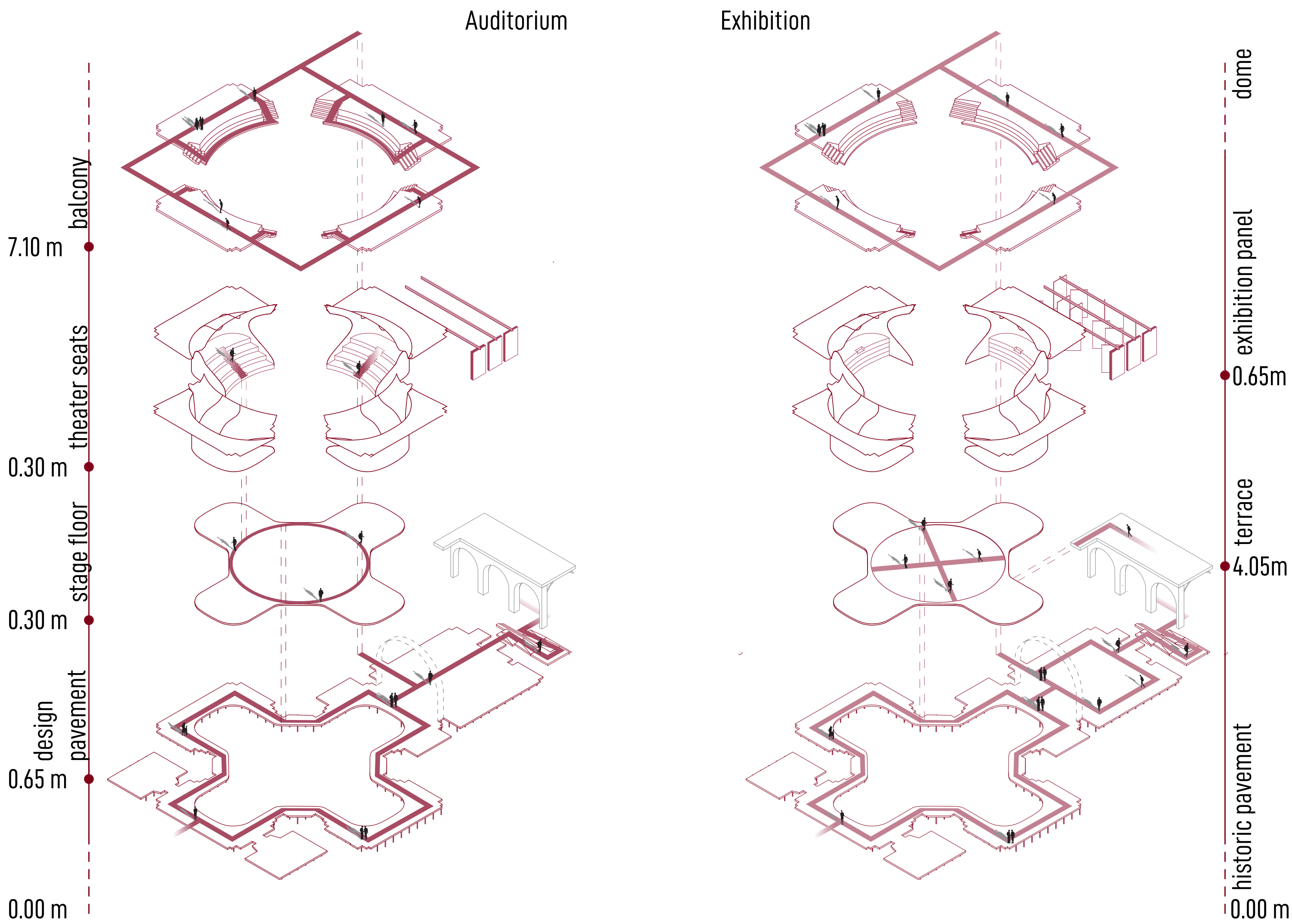
SECOND FLOOR PLAN



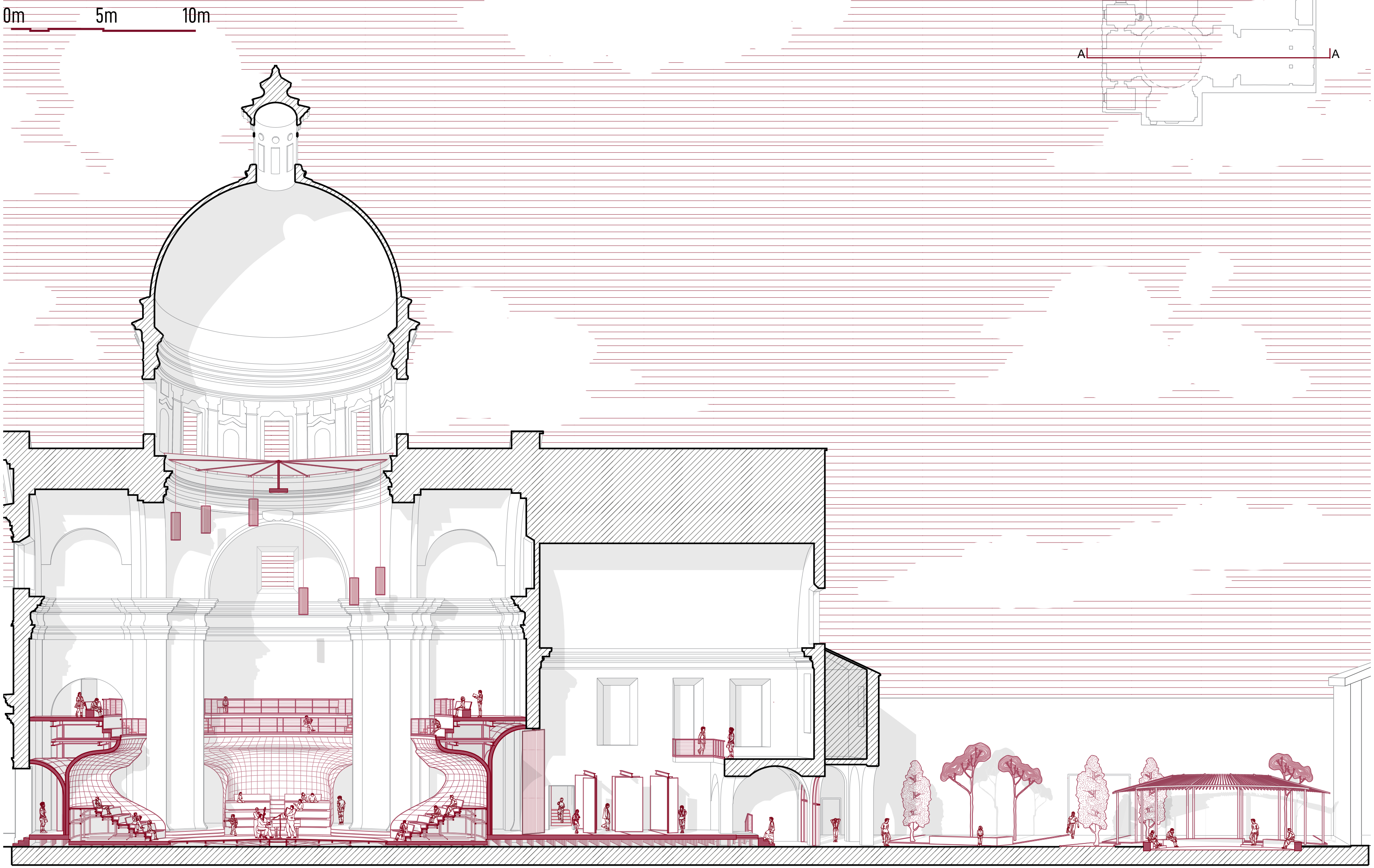
ENTRANCE CHLOISTER



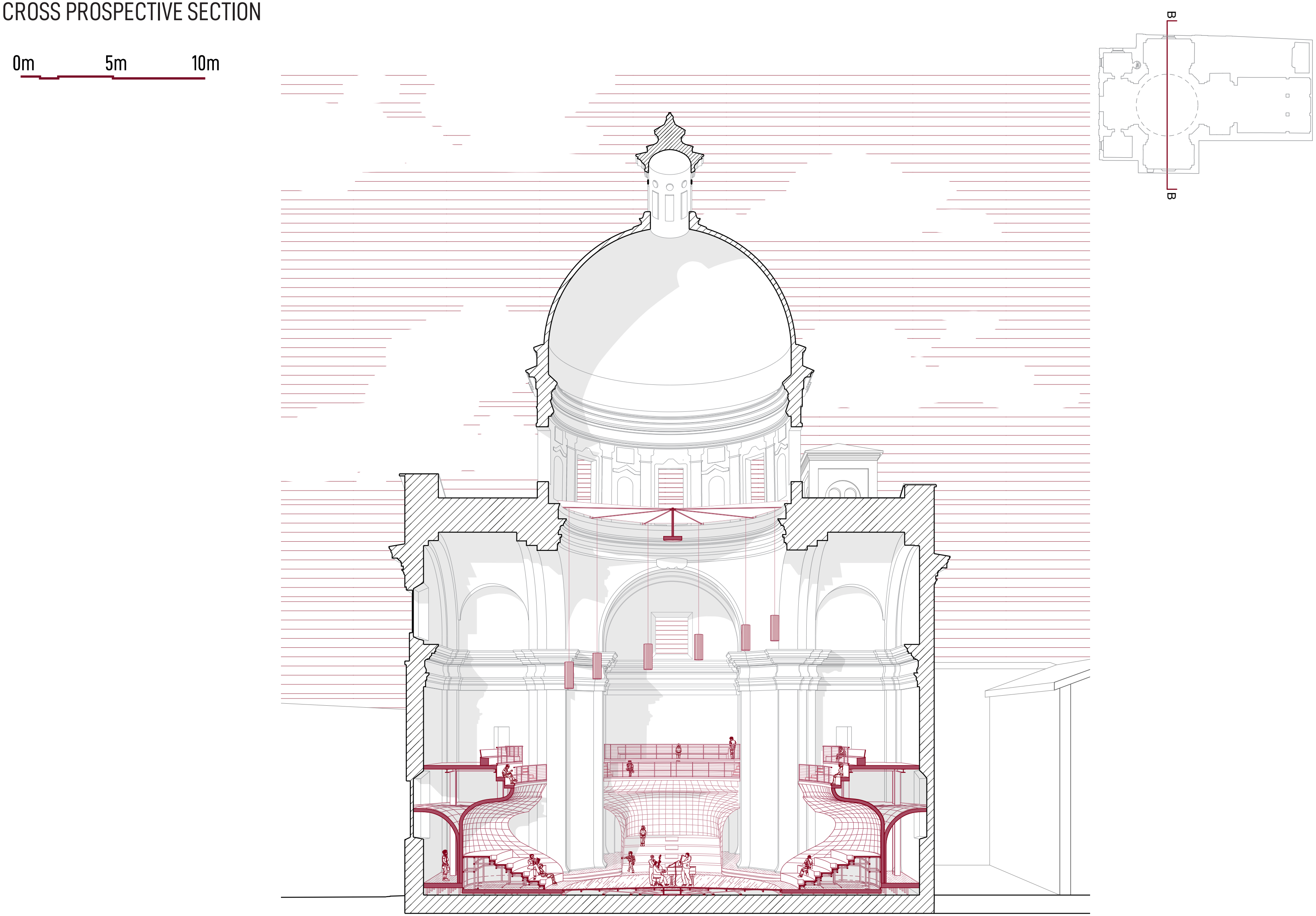
AXONOMETRY OF PATHS



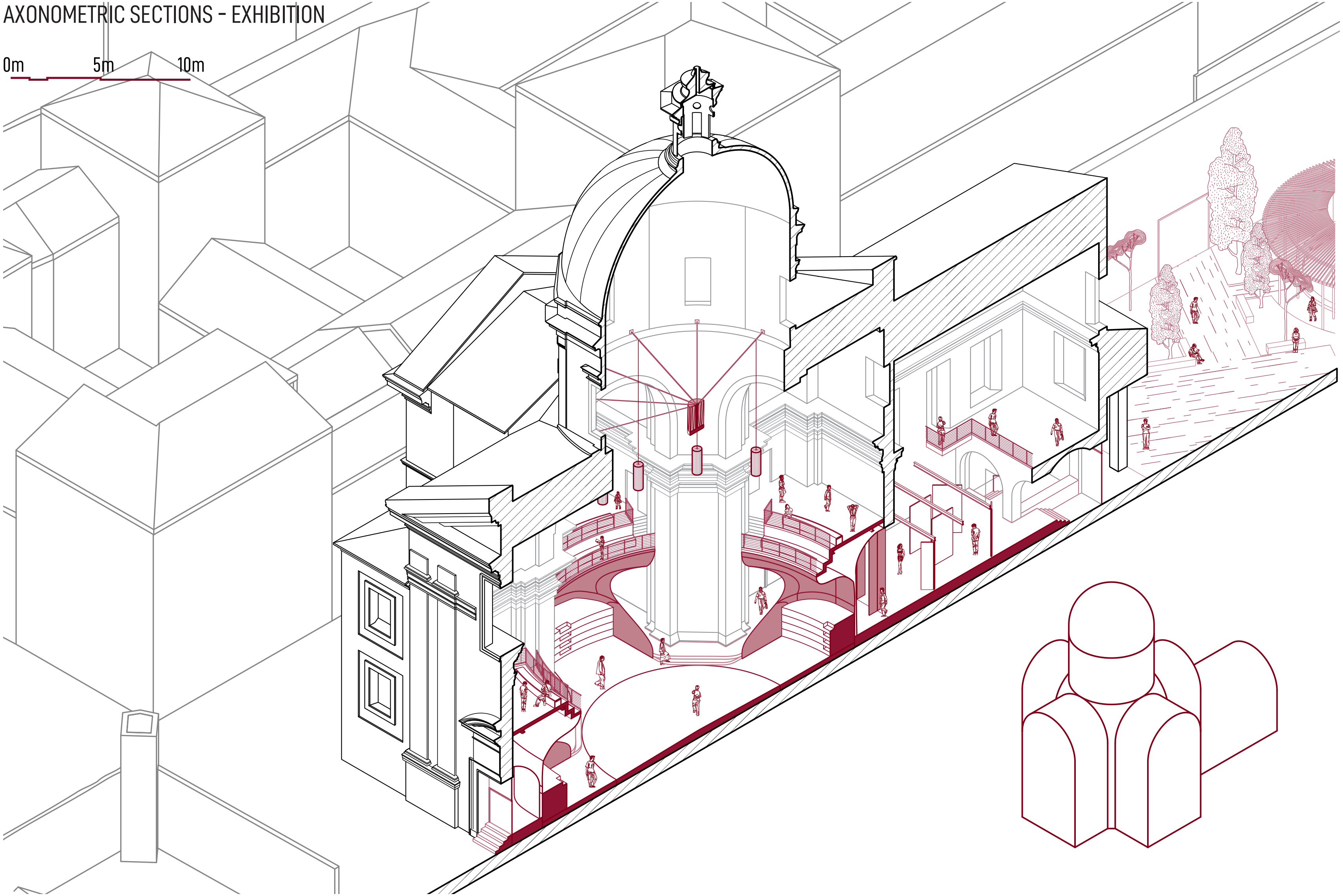
LONGITUDINAL PROSPECTIVE SECTION



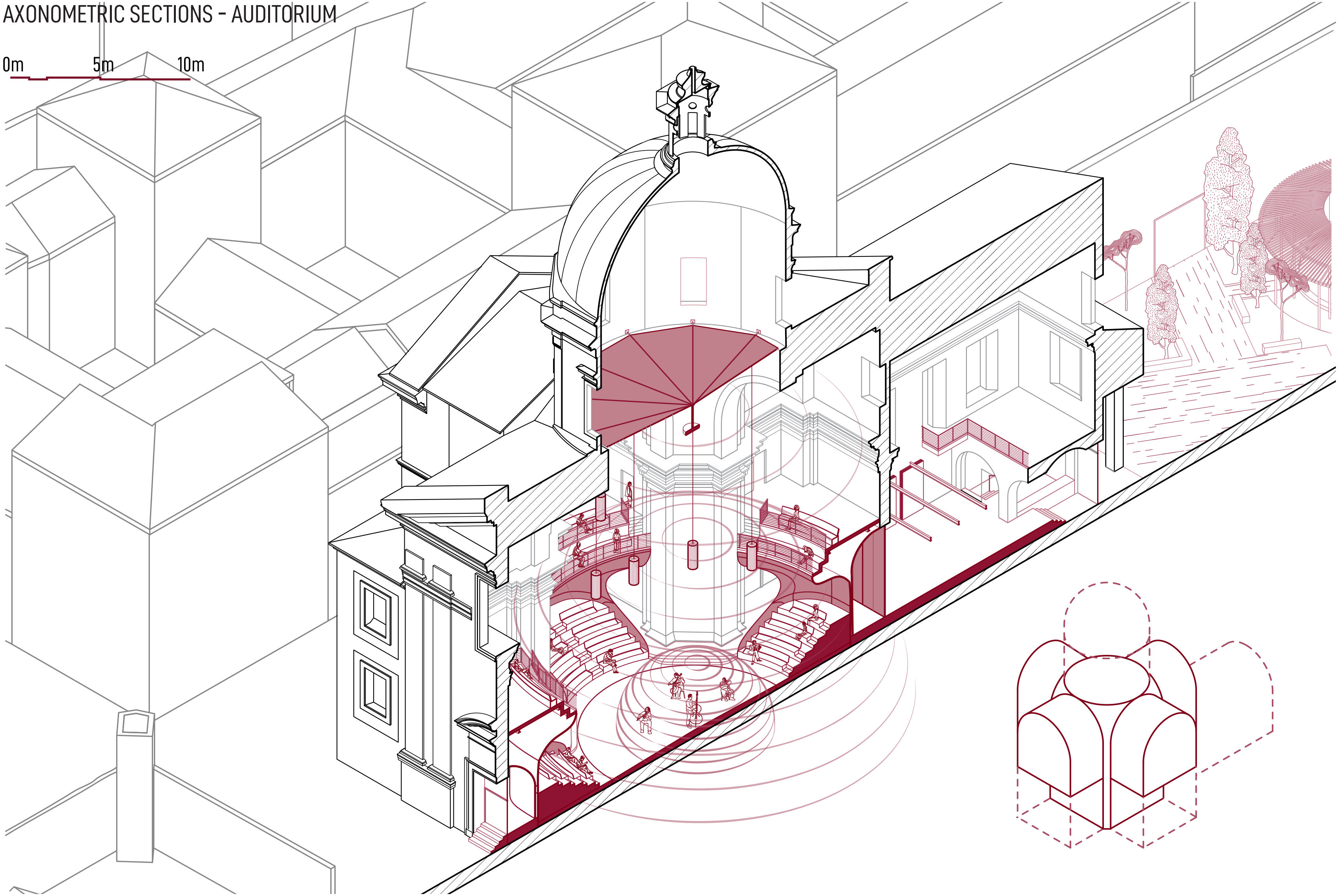
CROSS PROSPECTIVE SECTION



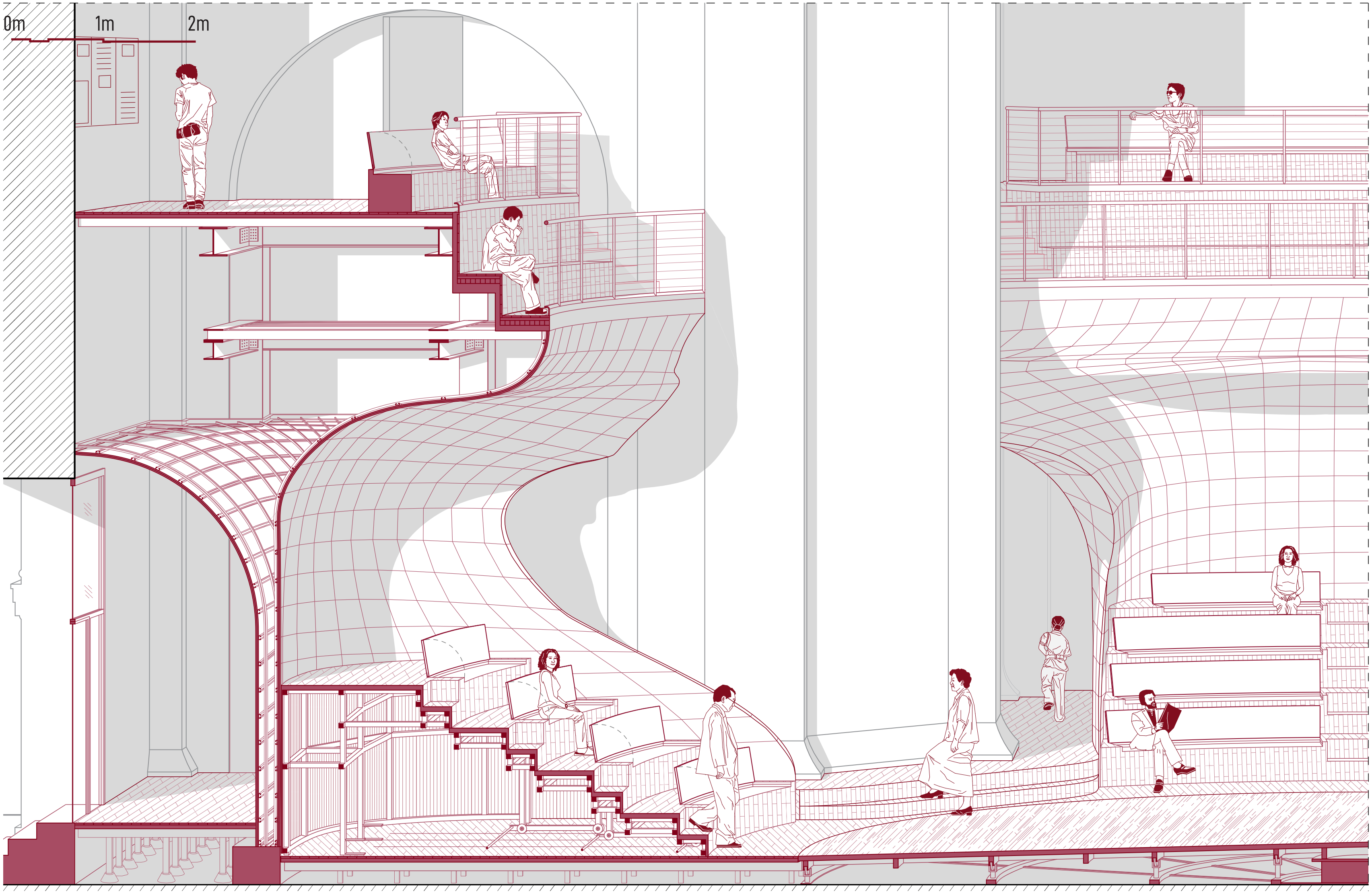
AXONOMETRIC SECTIONS - EXHIBITION



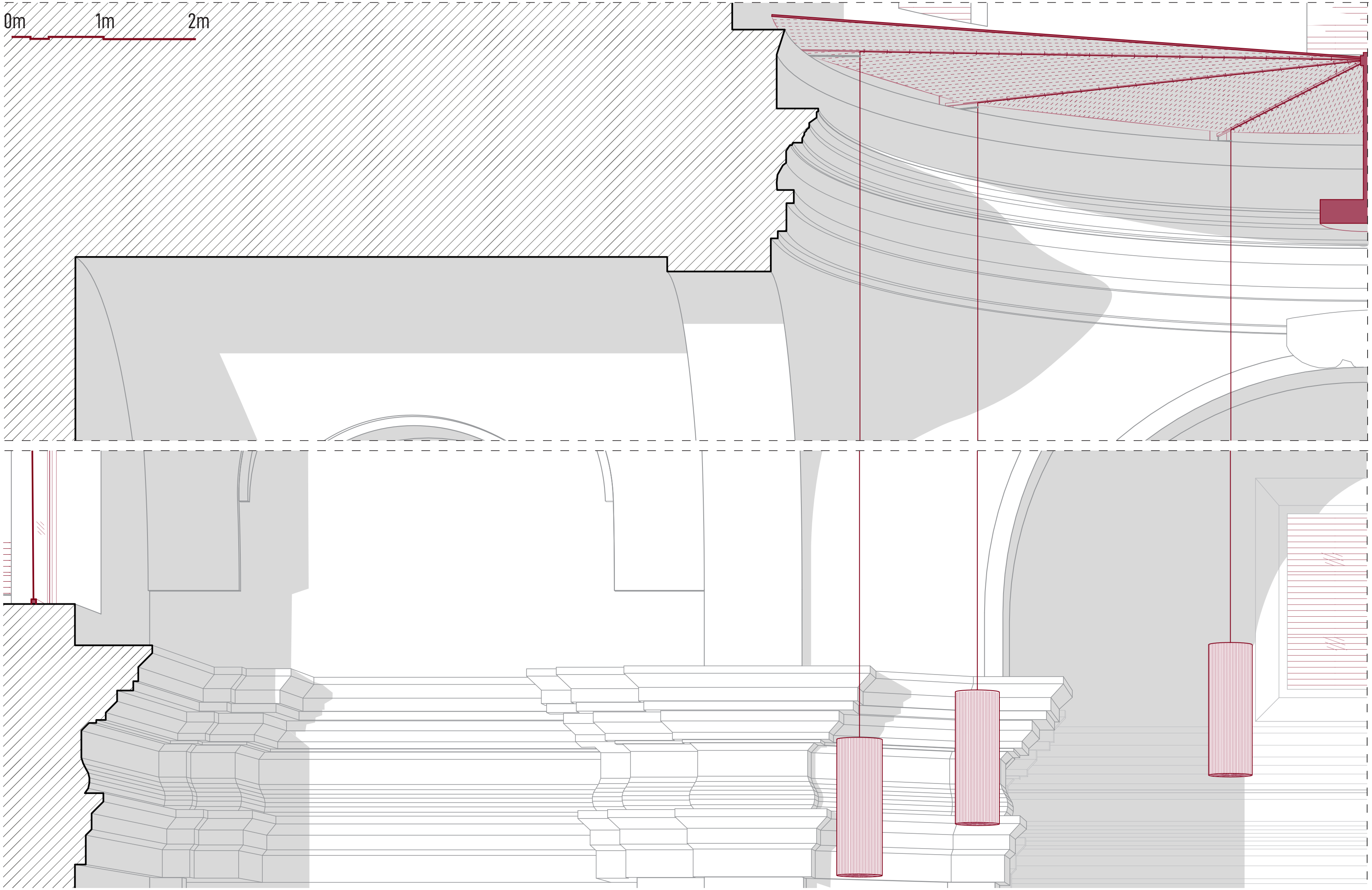
AXONOMETRIC SECTIONS - AUDITORIUM



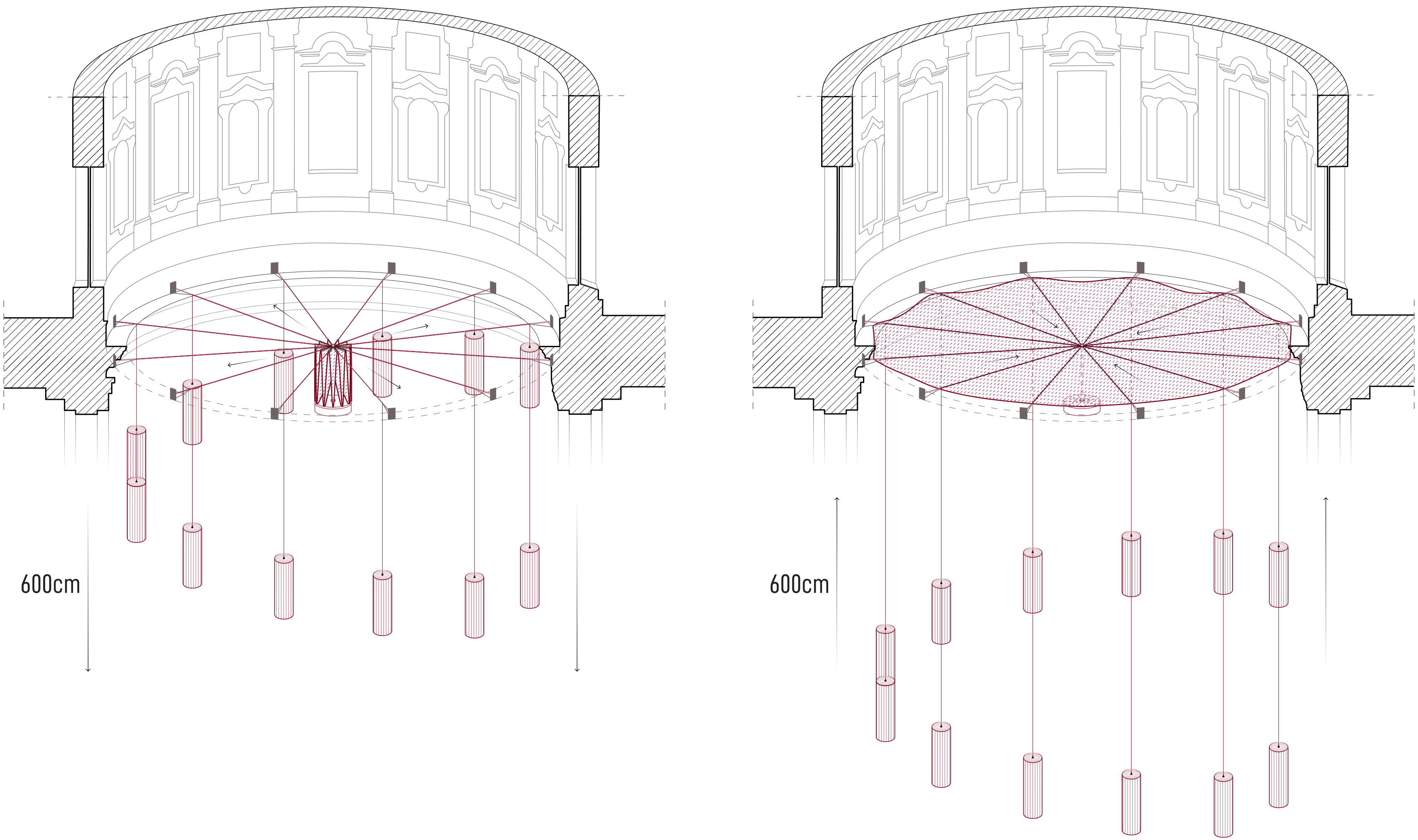
DETAILED PERSPECTIVE SECTION



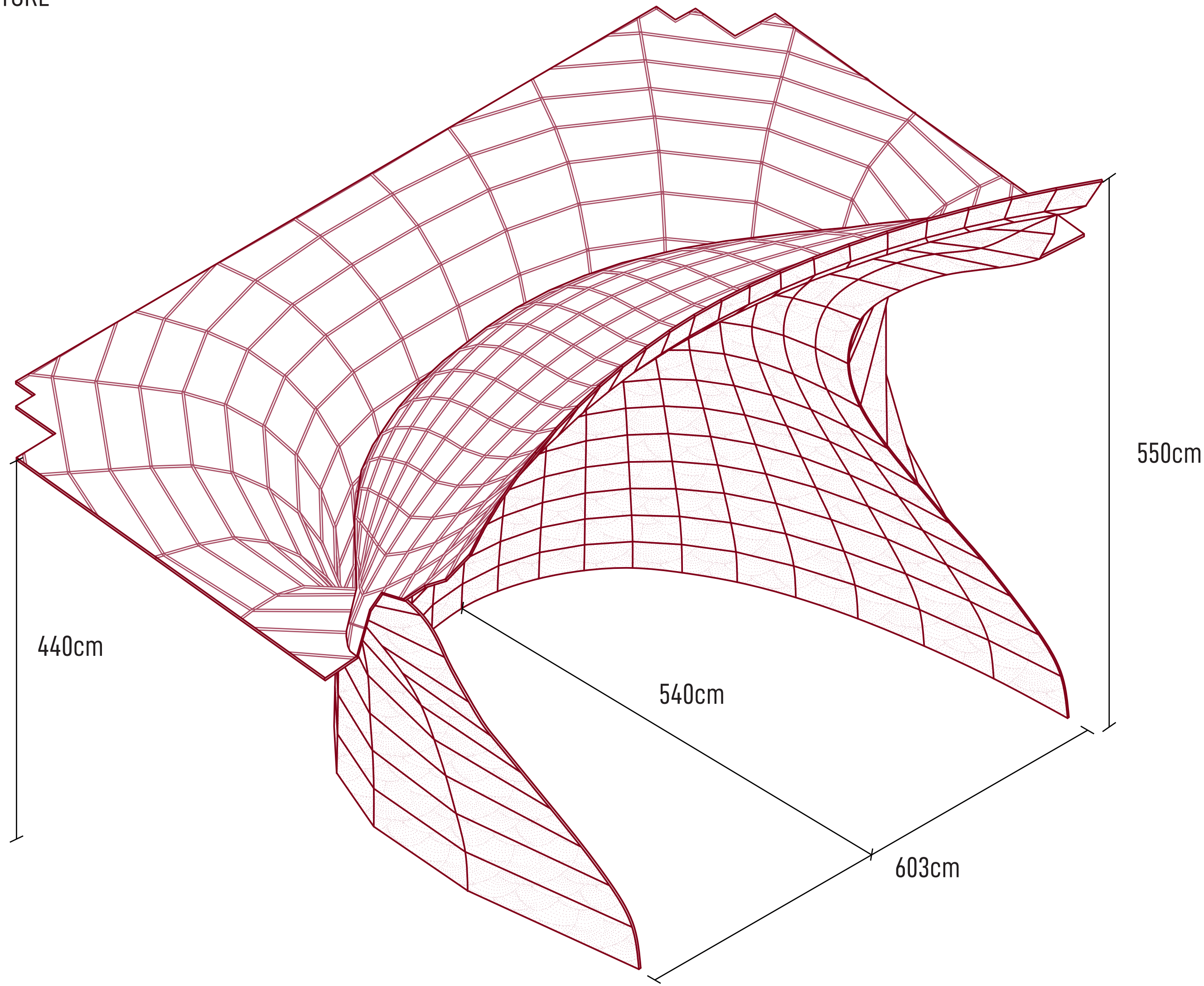
DETAILED PERSPECTIVE SECTION



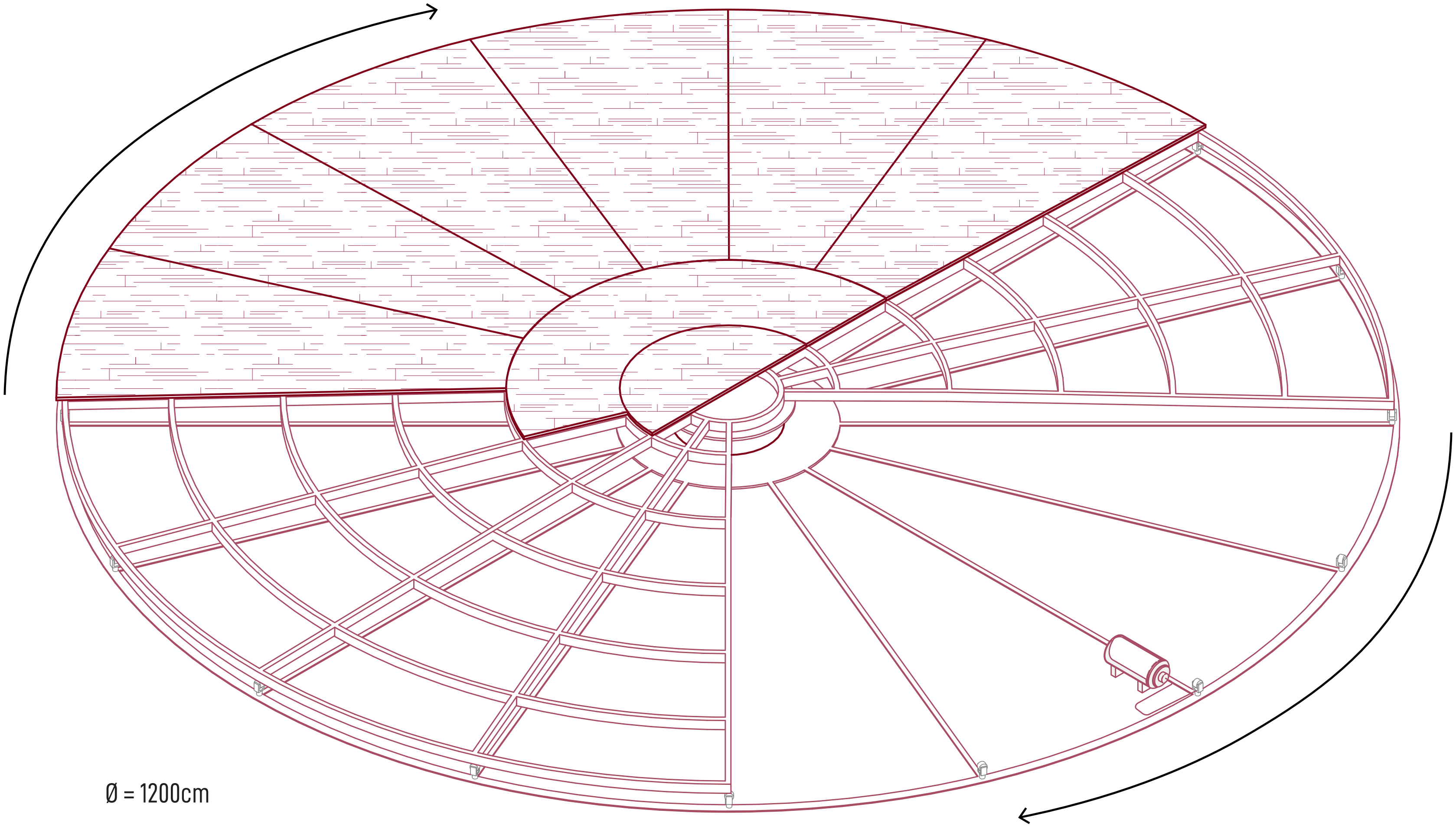
DOME CLOSURE (OPEN / CLOSED)



SAIL CURVE STRUCTURE

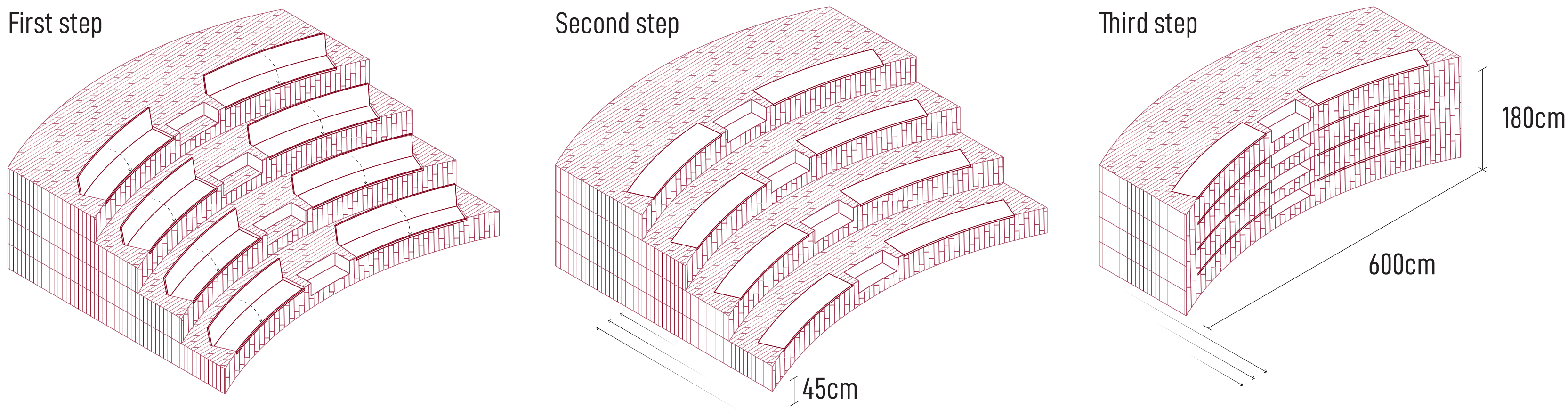


TURNTABLE STAGE

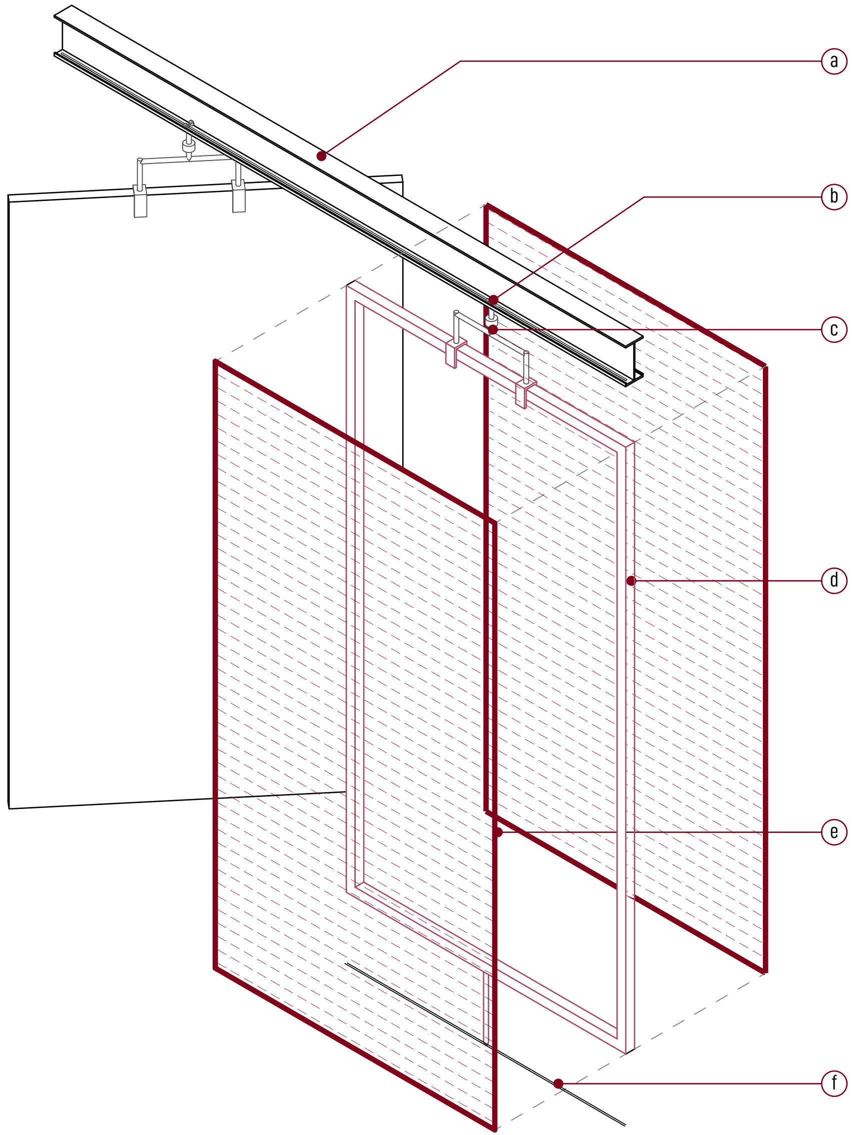


Ø = 1200cm

FOLDING TIERED SEATING



EXHIBITION PANELS



a Beam with groove - IPE 20cm

b Sliding trolley

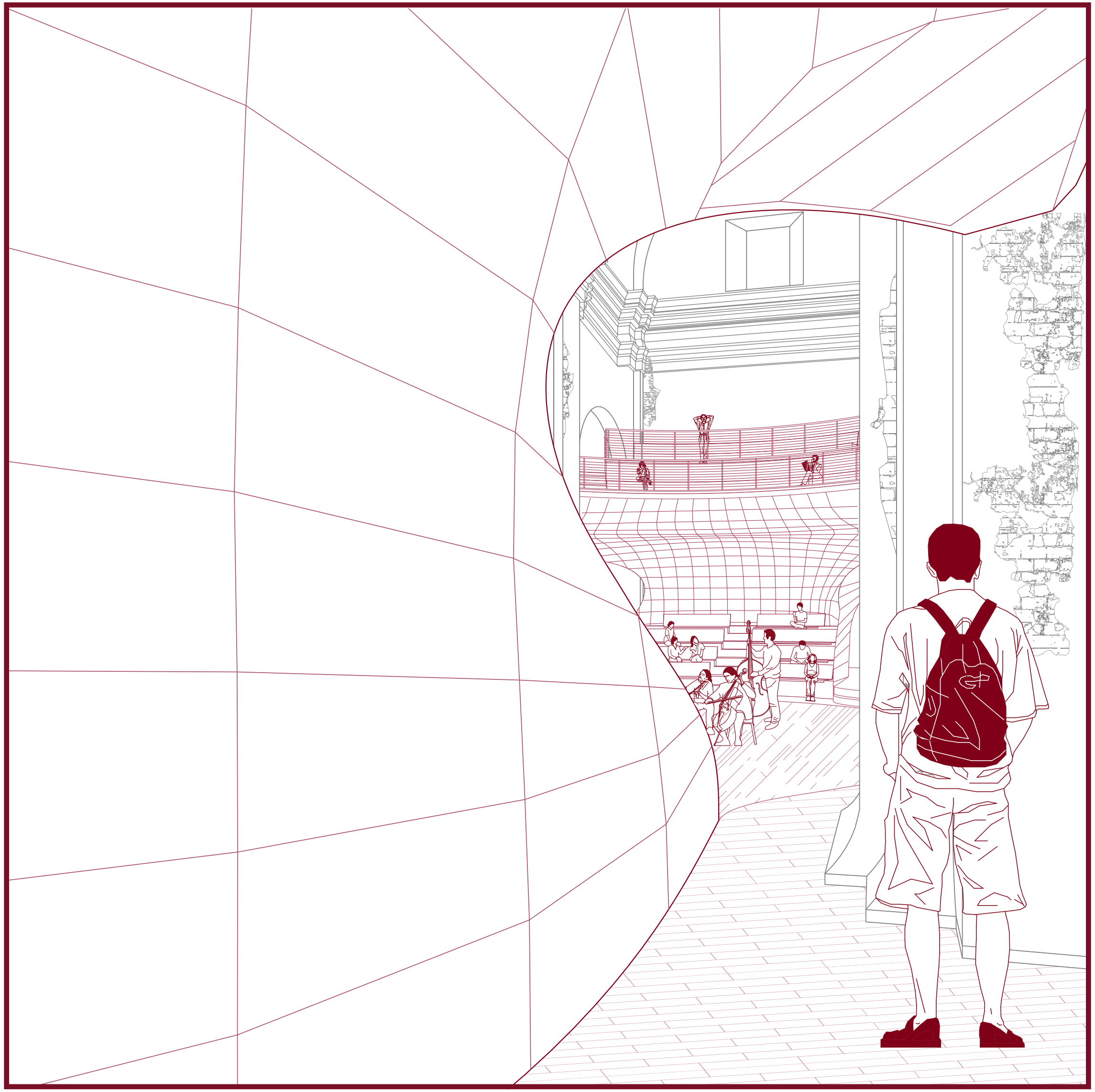
c Hanger with rotating bearing

a Alluminium frame - 3cm

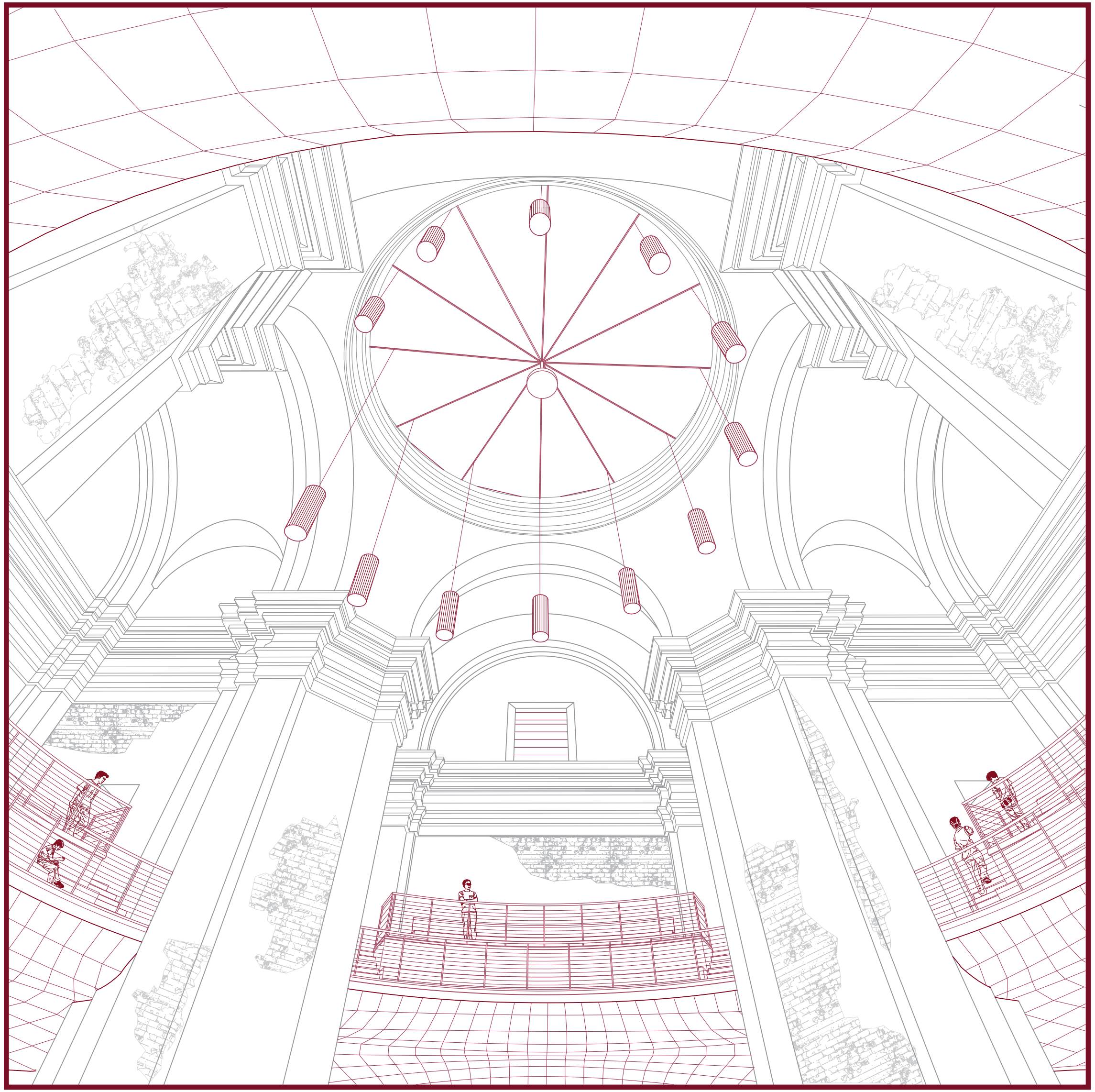
b Cladding sheet - 0.2cm

c Ground guide support

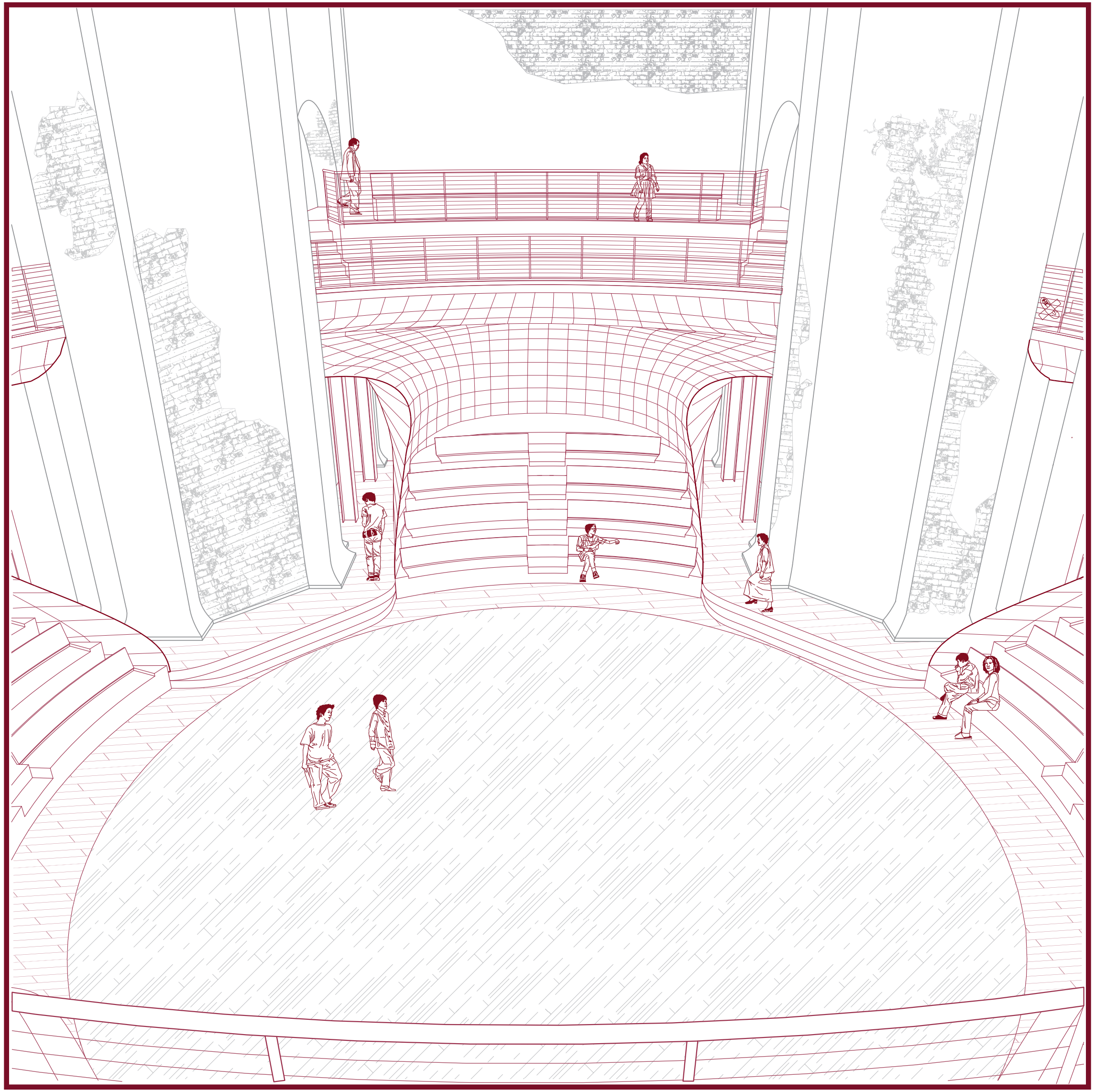
AUDITORIUM TUNNEL



DOME CLOSURE

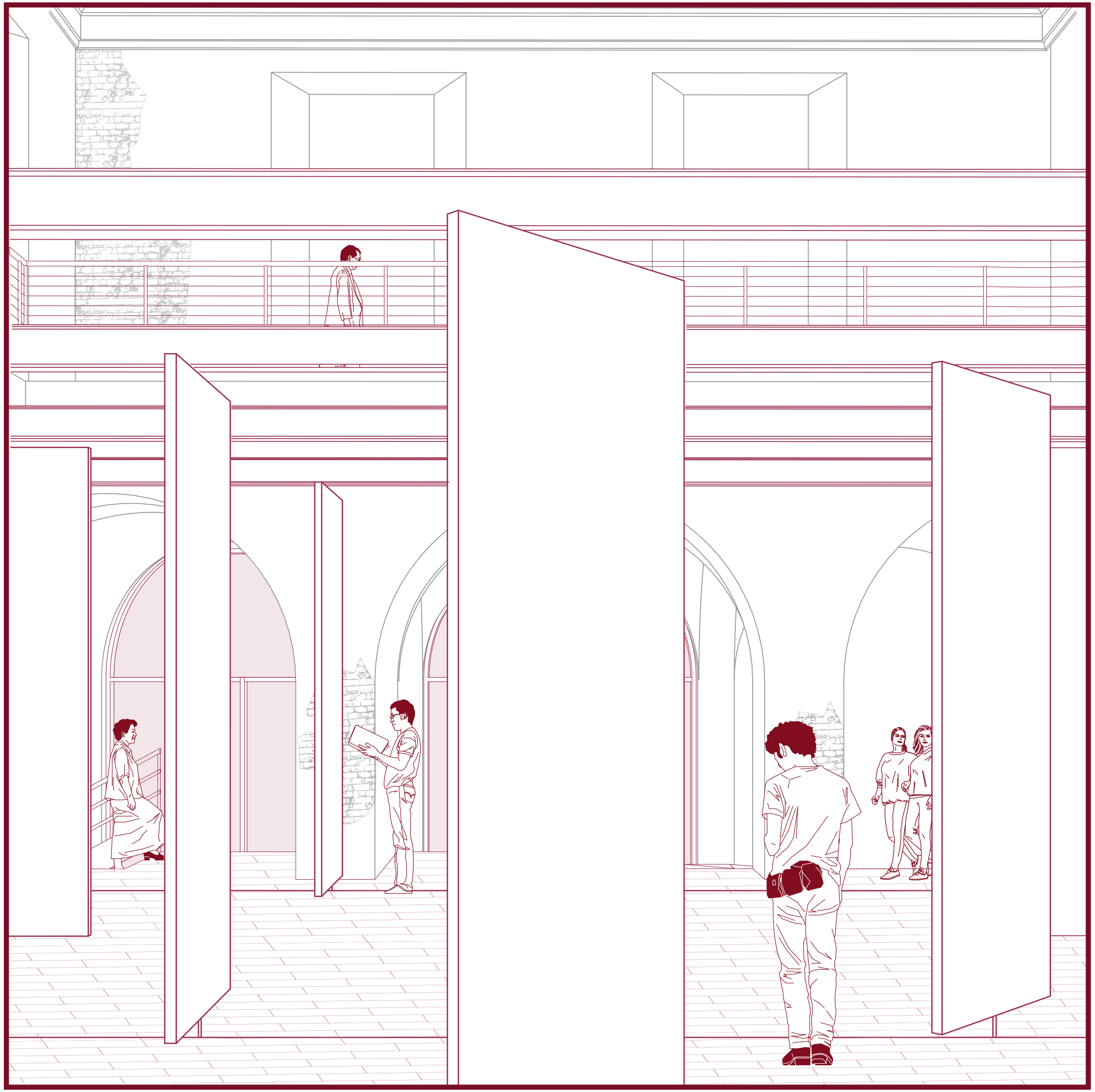


STAGE VIEW FROM THE BALCONY

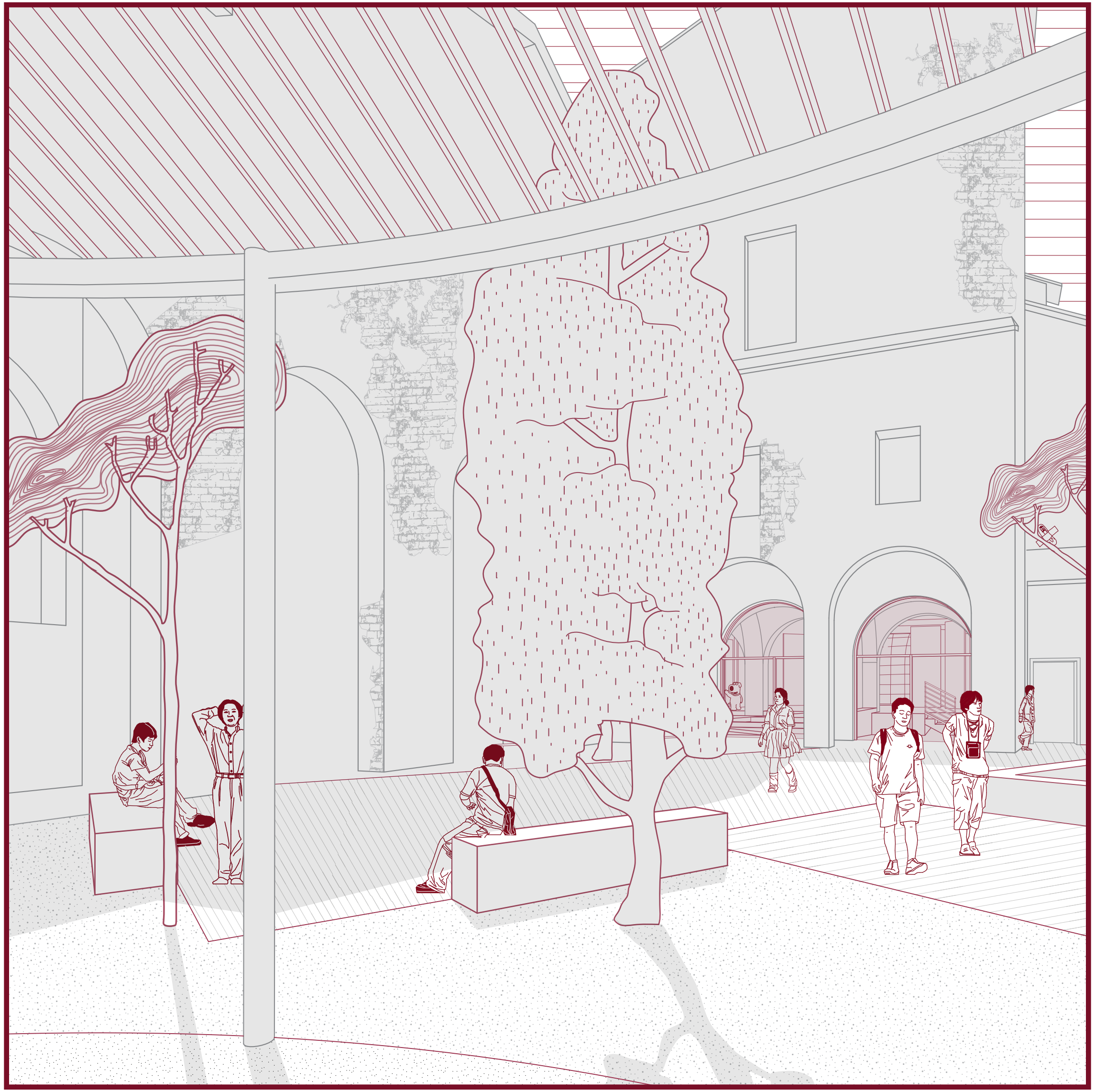


BALCONY EXHIBITION AREA

EXHIBITION AREA



ENTRANCES'S CLOISTER



03.3 Technical acoustic solutions

ACOUSTIC SOLUTIONS

To transform the church into a concert hall, it was necessary to solve the problems that emerged from the acoustic analysis: the long reverberation time and the resulting reduction in intelligibility and sound clarity.
The renovation work was carried out in two main directions: on the one hand, the volume of the entire church had to be reduced, and on the other hand, acoustic materials and custom-made devices had to be introduced.
The volume reduction was achieved by means of mobile and reversible technical solutions, such as curtains that close the dome and canvas structures in the transepts. These interventions make it possible to reduce reverberation time without permanently damaging the historic building and give the environment a new flexibility and value.

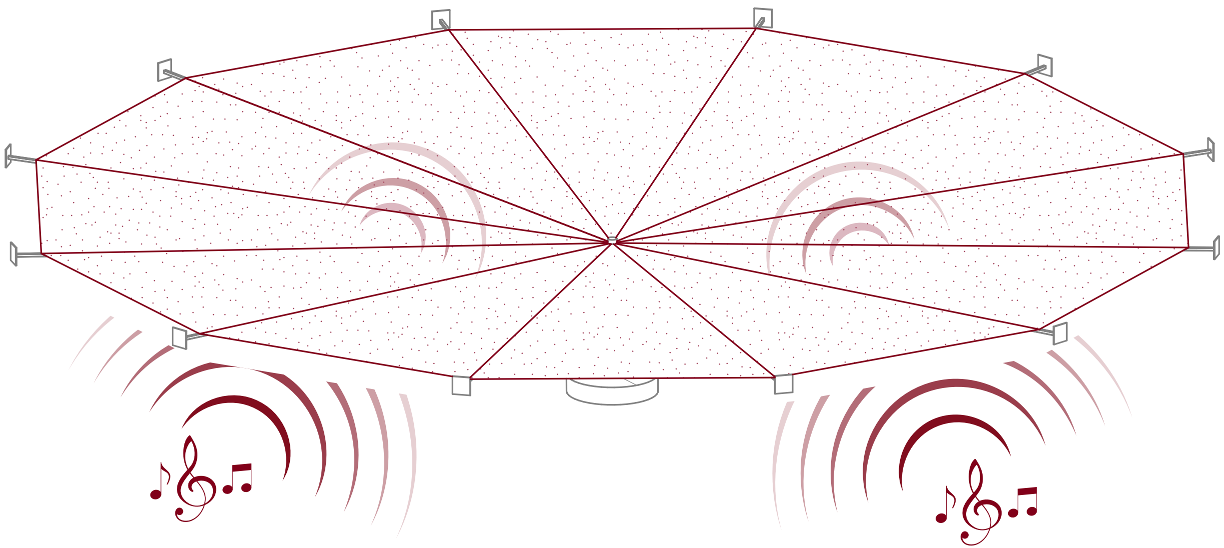
The choice of materials was not random, but made according to clear criteria. Each element was selected not only according to its compatibility with the existing architecture, but also according to its ability to absorb sound in a certain frequency band. For example, plasterboard panels act as resonance panels in the low and medium frequency bands. Bass traps are designed for the lower frequency band (125-250 Hz), while fabrics and curtains improve speech intelligibility in the medium frequency bands. Wood, on the contrary, thanks to its natural reflective properties, maintains the liveliness and clarity of the space.

The result is that the combination of these solutions has radically changed the acoustic properties of the church. The space, which due to excessive reverberation was unsuitable for listening, has been transformed into a controlled environment and reborn as a functional and at the same time evocative space. It has become a place that respects the historical identity while offering a unique acoustic experience.

DOME CLOSURE - ACOUSTIC CURTAIN

The dome closure is designed as a large, movable acoustic curtain that, when extended below the drum, reduces the volume of the church and limits the dispersion of sound upwards. The system uses bass traps as counterweights: when these are lowered, they pull the curtain unfolding horizontally at the centre of the base of the dome cylinder.

This movement combines two effects: on the one hand, the geometric reduction of the volume, and on the other, the proper positioning of the bass traps. The result is a clear improvement in sound clarity and a noticeable reduction of the reverberation time.



BASS TRAPS

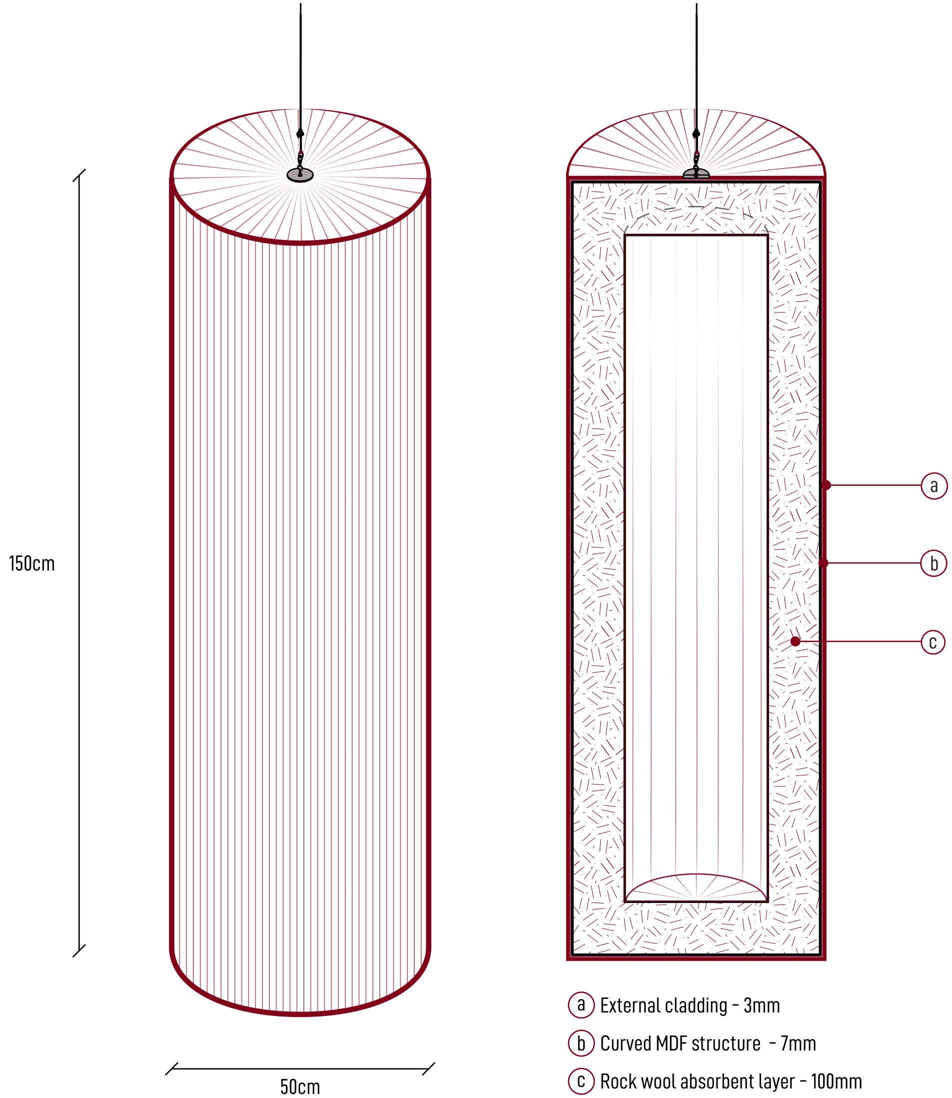
In the central part of the auditorium, 12 cylindrical bass traps hang above the stage, elements specifically designed to control low frequencies, which were the most critical issue that emerged from the measurements.

The curved structure of these traps, combined with a high-density rock wool core, allows them to selectively absorb low sounds by reducing stationary waves and energy build-up in the first octave bands (125-250 Hz).

Bass traps are also height-adjustable, a feature that makes it possible to distribute their absorbing effect along the entire vertical of the church, ensuring a more uniform and complete acoustic treatment.

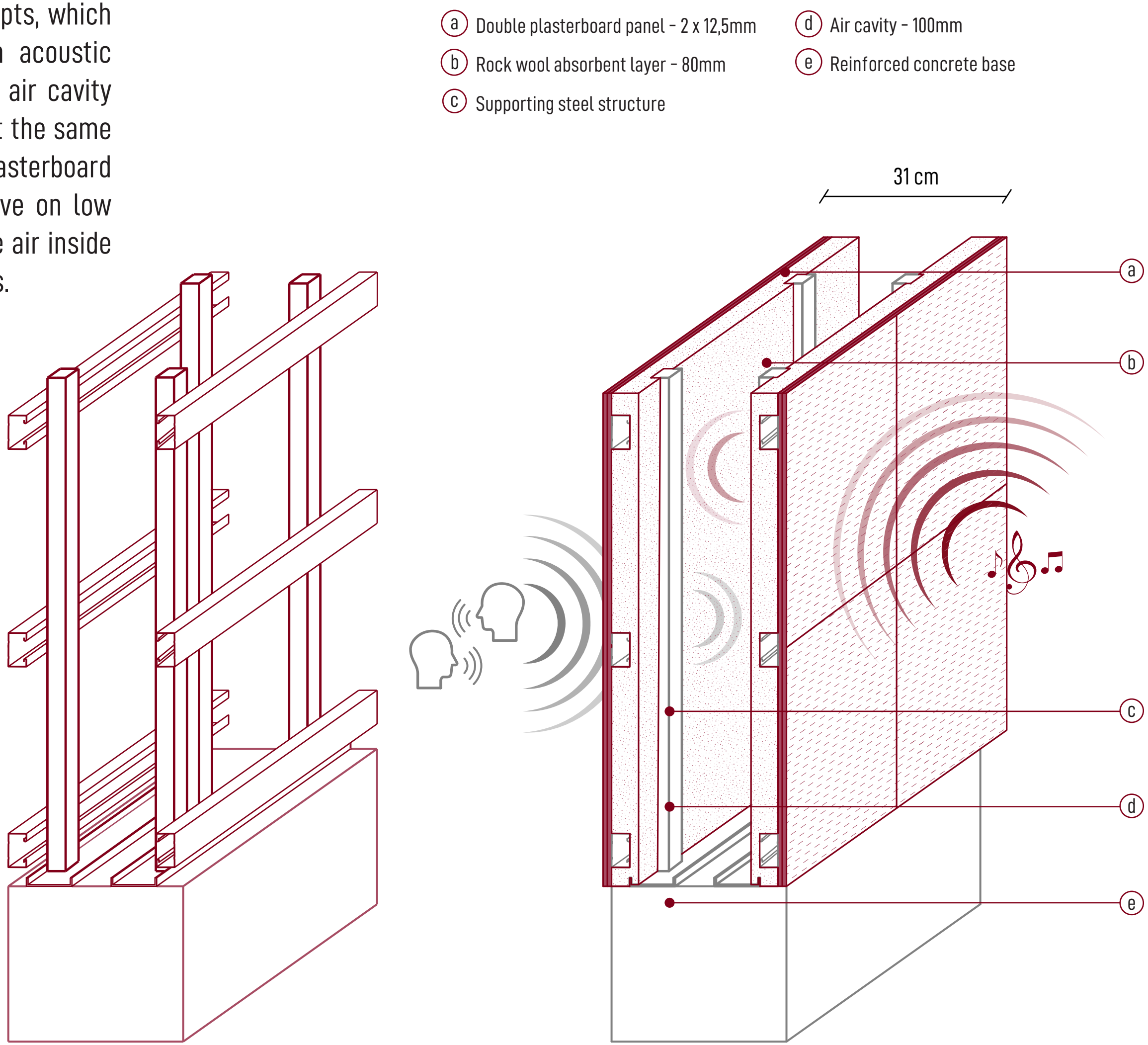
In addition to their primary function of absorption, these devices also act as a counterweight for the dome's closure system: when lowered, they draw the horizontal curtain that completely closes the base of the dome, decreasing the total volume of the room and improving the overall acoustics.

Thanks to this combination of functions, bass traps not only attenuate the long tail sound of low frequencies, but also contribute to a more balanced and controlled acoustics.



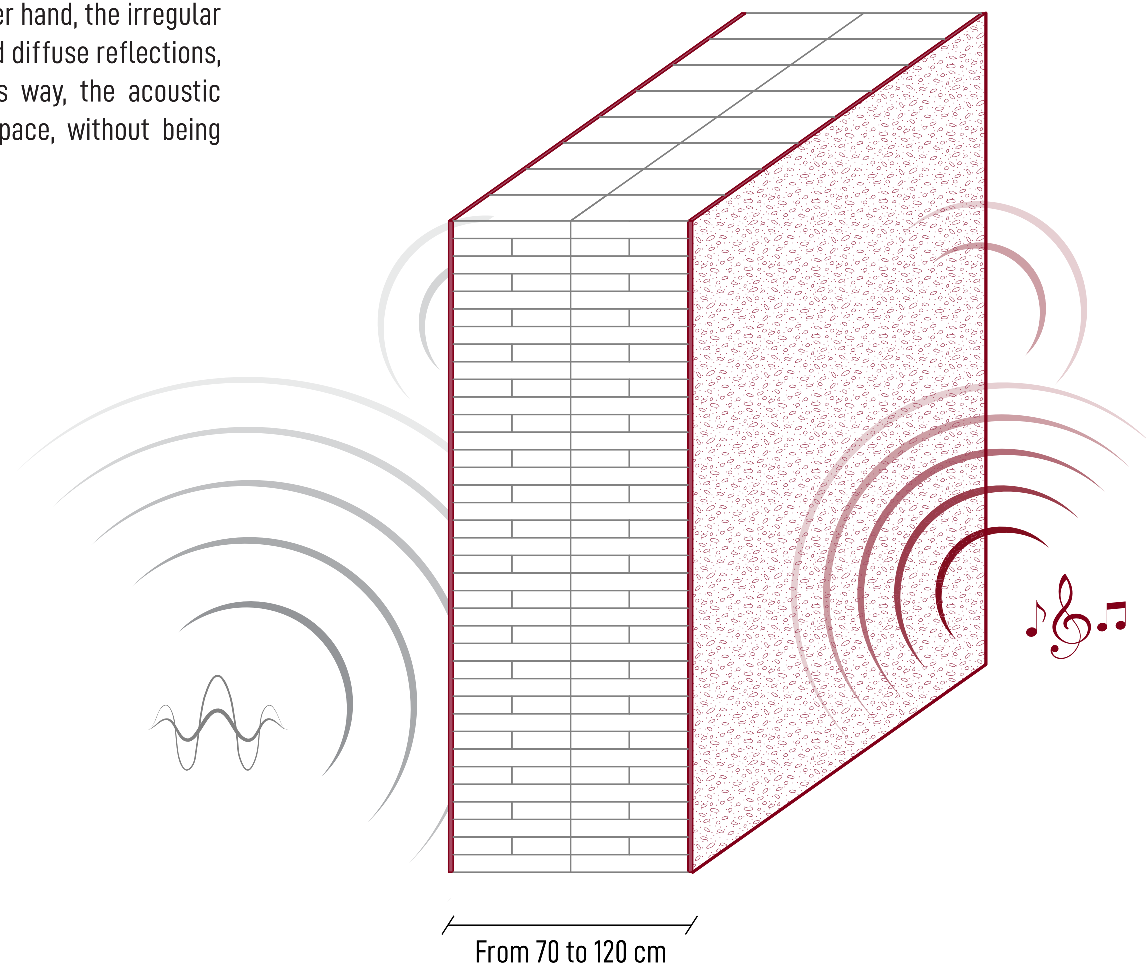
DOUBLE PLASTERBOARD AND INSULATION WALL

Plasterboard sails were inserted in the transepts, which have not only an architectural but also an acoustic function. Their double-wall structure with an air cavity reduces the total volume of the church and, at the same time, functions as an absorption system. The plasterboard vibrates like a resonant panel and is effective on low frequencies, while the different layers and the air inside help to attenuate the medium-high frequencies.



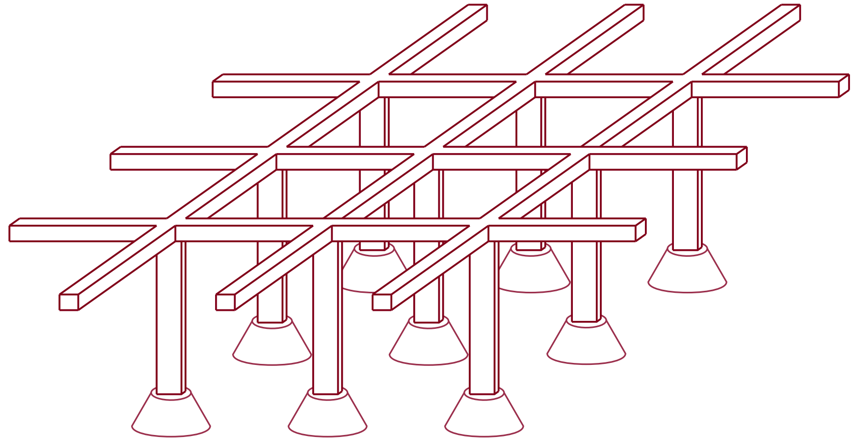
HISTORICAL MASONRY

The original masonry of the church, with its great thickness, has a merit that should not be underestimated: it isolates very well from external noise. Inside, on the other hand, the irregular surface of the plaster helps to break up and diffuse reflections, avoiding annoying direct rebounds. In this way, the acoustic quality is all played out in the interior space, without being disturbed by the surrounding urban context.



INSULATED RAISED TIMBER FLOORING

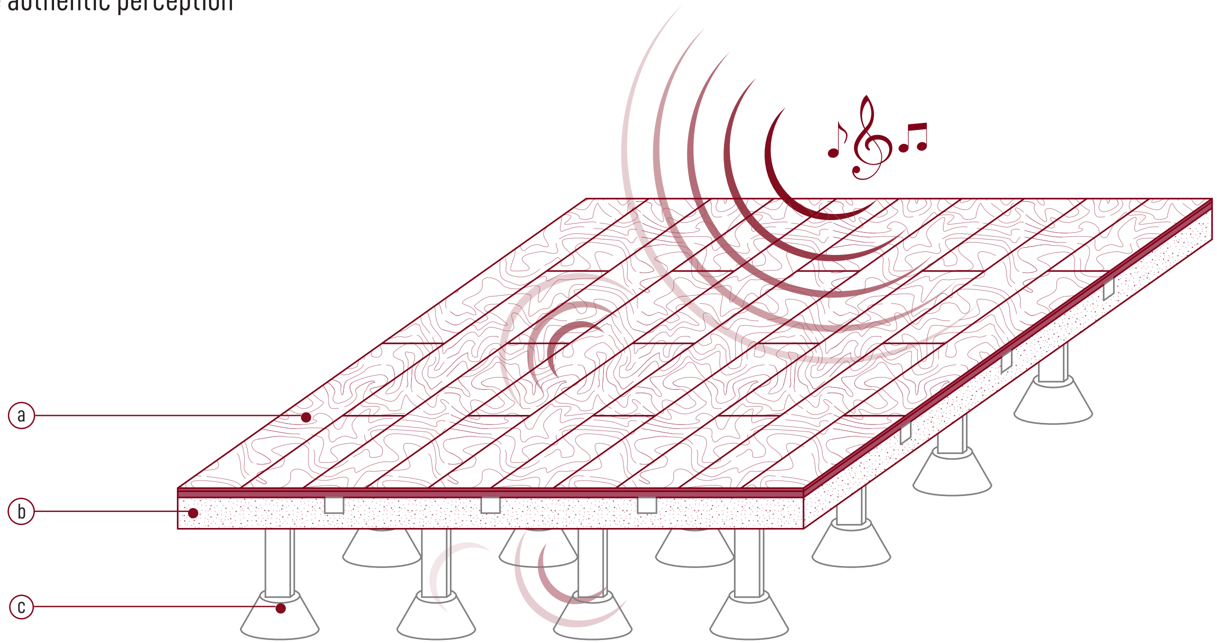
The new floor is designed to reduce footstep noise thanks to an insulating layer and an air gap underneath, but without losing the warmth and acoustic performance of wood. The support structure consists of a mesh of metal legs with adjustable feet, which allow the entire system to be laid without affecting the historic flooring below. The wooden surface retains its natural ability to reflect sound, restoring liveliness and brilliance to the room and preventing the acoustics from being overly dampened. The result is a balance between acoustic comfort and sound quality, which completes the entire intervention without altering the authentic perception of the space.



(a) Timber flooring

(b) Rock wool absorbent layer - 80mm

(c) Supporting steel structure



03.4 Sabine calculation - State of project

SABINE CALCULATION – STATE OF PROJECT

The new calculation based on Sabine's formula made it possible to estimate the acoustic behavior of the church in its projected design, considering the materials used and their layout. The results immediately showed a significant reduction in reverberation time compared to the very high values found during the site inspection.

The plasterboard walls of the sails function as resonant panels capable of intervening on low frequencies, thus proving to be fundamental in correcting the main critical issue of the church. These are complemented by curtains, which increase absorption at mid and high frequencies, and bass traps, designed to reduce the persistence of low frequencies. The timber floor and masonry surfaces maintain a reflective component that helps preserve the brightness of the sound, balanced by the new absorbent surfaces.

The calculation of volumes and surfaces during the design phase inevitably differs from the initial calculation, as several solutions have contributed to significantly reducing the overall volume of the church. The fabric covering the dome, positioned immediately below the drum, and the sails located in the transepts significantly reduce the total volume in cubic metres, thus optimising acoustic performance and improving the effectiveness of interventions.

Volumetric computation results

- Vtot = 5.700 m^3

Surfaces calculation results:

Surface	m^2
Plasterboard wall panels	280
Wooden flooring	650
Glass	25
Historic plastered masonry	2125
Acoustic curtains	130
Bass trap	25

Sound absorption coefficient per octave band:

Surfaces	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Plasterboard wall panels	0,3	0,5	0,75	0,75	0,8	0,9
Wooden flooring	0,15	0,25	0,35	0,4	0,5	0,45
Glass	0,18	0,06	0,04	0,03	0,02	0,02
Historic plastered masonry	0,08	0,09	0,12	0,16	0,22	0,24
Acoustic curtains	0,05	0,1	0,2	0,3	0,3	0,35
Bass trap	0,25	0,5	0,7	0,8	0,8	0,7

RESULTS

A comparison between the data collected during the site inspection and those calculated in the project design clearly shows the improvement in quality achieved: the long initial decay times, often exceeding 5–6 seconds, have been reduced to much lower values, around 2 seconds in the mid-low frequencies and less than a second in the high frequencies. This means that the church, which was once excessively reverberant, has become an acoustically controlled space, closer to the standards required for an auditorium. This improves clarity, speech intelligibility and listening comfort.

The acoustic experience inside the Benedictine Church will never be the same as that of a modern concert hall: it will be a different listening experience, enriched by the unique character and architectural beauty of this extraordinary historical building.

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
T60 - State of project	**2,49**	**1,76**	**1,25**	**1,06**	**0,85**	**0,82**
T60 acoustic survey	6,07	5,65	5,28	4,29	3,22	1,74

CONCLUSIONS

The study presented in this thesis demonstrates that reusing the former Benedictine church as an auditorium with an integrated exhibition space is technically and culturally feasible, provided it is guided by principles of reversibility and flexibility.
The proposed layout – relocating the main entrance to the rear via the cloister, integrating architectural acoustic systems, and refining the internal organisation – preserves the integrity of the building while allowing the space to adapt to diverse musical and exhibition programmes over time. This framework offers a replicable model for other disused buildings.

A "data based" approach – metric survey with point cloud, acoustic measurement campaign and predictive modelling – provided a solid basis for decision making. Reference measurements revealed a T60 of 5–6 s with an excessive low frequency tail. Design simulations, thanks to the reduction in internal volume (≈11,200 m^3 to ≈5,700 m^3) and the introduction of sound absorbing materials and devices, bring reverberation to values suitable for chamber and choral music; the aim is not to emulate the best concert halls, but to offer a distinctive visual and auditory experience. The alignment between experimental measurements and Sabine's estimates confirms the reliability of the model used to calibrate the architectural solutions.

The intervention can proceed only after a preliminary phase of cleaning, restoration, and stabilisation/safety works – already initiated in recent months – given the building's prolonged disuse. This phase is essential to remove deposits and incongruous materials, arrest urgent decay, consolidate roof, vaults, and decorative elements, and restore minimum access and safety conditions. Beyond safeguarding workers and users, these operations enable precise calibration of subsequent design choices, avoiding invasive measures and preserving historic surfaces; only on a stabilised and legible structure will it be possible to install new equipment in a reversible manner.
In sum, the project advances an active-conservation strategy that combines acoustic quality with heritage enhancement, providing Piacenza with a flexible and distinctive cultural venue.

Our thesis is oriented towards sustainability rather than restoration; it adopts reuse as a strategy to maximise resource efficiency. Working with the existing fabric means enhancing the building stock, reducing land take and embodied-carbon emissions, limiting new materials and waste, and regenerating neglected parts of the city. This is a measurable, long-term approach.

In the contemporary dilemma between aspirations for progress and ecological limits, sustainability does not mean adding but caring: reactivating a disused space and returning it to the community as a place for music and artistic expression reduces environmental impacts while rebuilding social ties. It is an act of intergenerational responsibility that seeks to leave future generations a stronger legacy and a lighter ecological footprint.

project manifesto

Current condition

The regeneration of degraded spaces is the most concrete expression of sustainability: it conserves building capital, avoids new construction, reduces land consumption and embodied carbon emissions and returns use value to the community.
The reuse of the former Benedictine Church is the objective of this thesis. The project focuses on the functional redesign of the building, but at the same time opens up broader scenarios of urban regeneration, with the aim of restoring value to an area currently characterised by neglect, decay and a general state of decay.

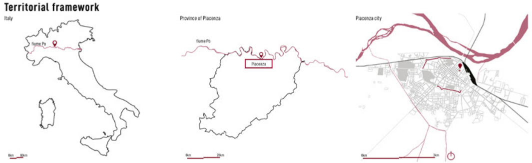
Project goal

The project aims to create a unique auditorium, designed to host musical, cultural and performing arts events, in line with the history and spirit of the place. This space also includes an exhibition area, which guides visitors on an immersive journey, highlighting the architectural beauty of the church and narrating its identity.
The exhibition hall and auditorium coexist in a single, flexible environment, designed to adapt to the different needs that the city may express over time.
This adaptability is not only a design choice, but a thread that runs through the building's entire history: over time, the church has always changed its function of use, each time responding to the different needs of society. Over the centuries, it has been transformed from a place of worship to a military depot and then to a governmental defence space.

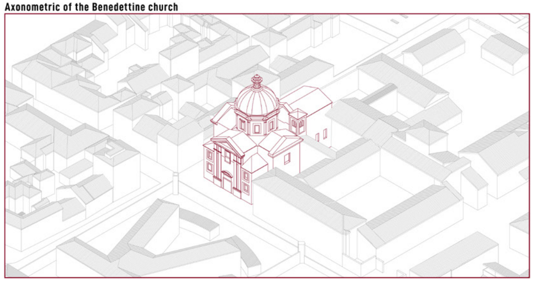
Regeneration

Today, with this new project, there is an opportunity to return it to the community as a living, accessible place, rich in memory and ready to welcome new forms of expression, without covering up the signs of time with the intention of keeping alive the memory of the history and periods that have characterised the building's life.

Territorial framework



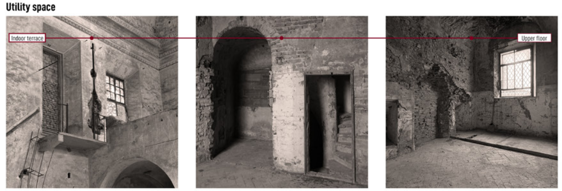
Axonometric of the Benedettine church



Bounderies

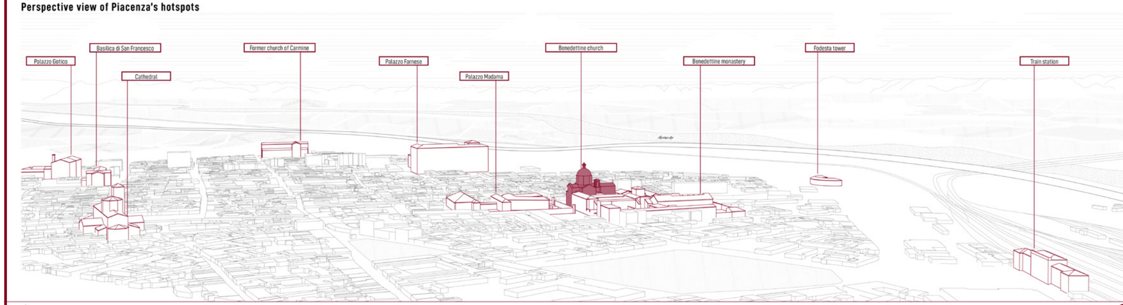
Verticality

Utility space



Material

Perspective view of Piacenza's hotspots



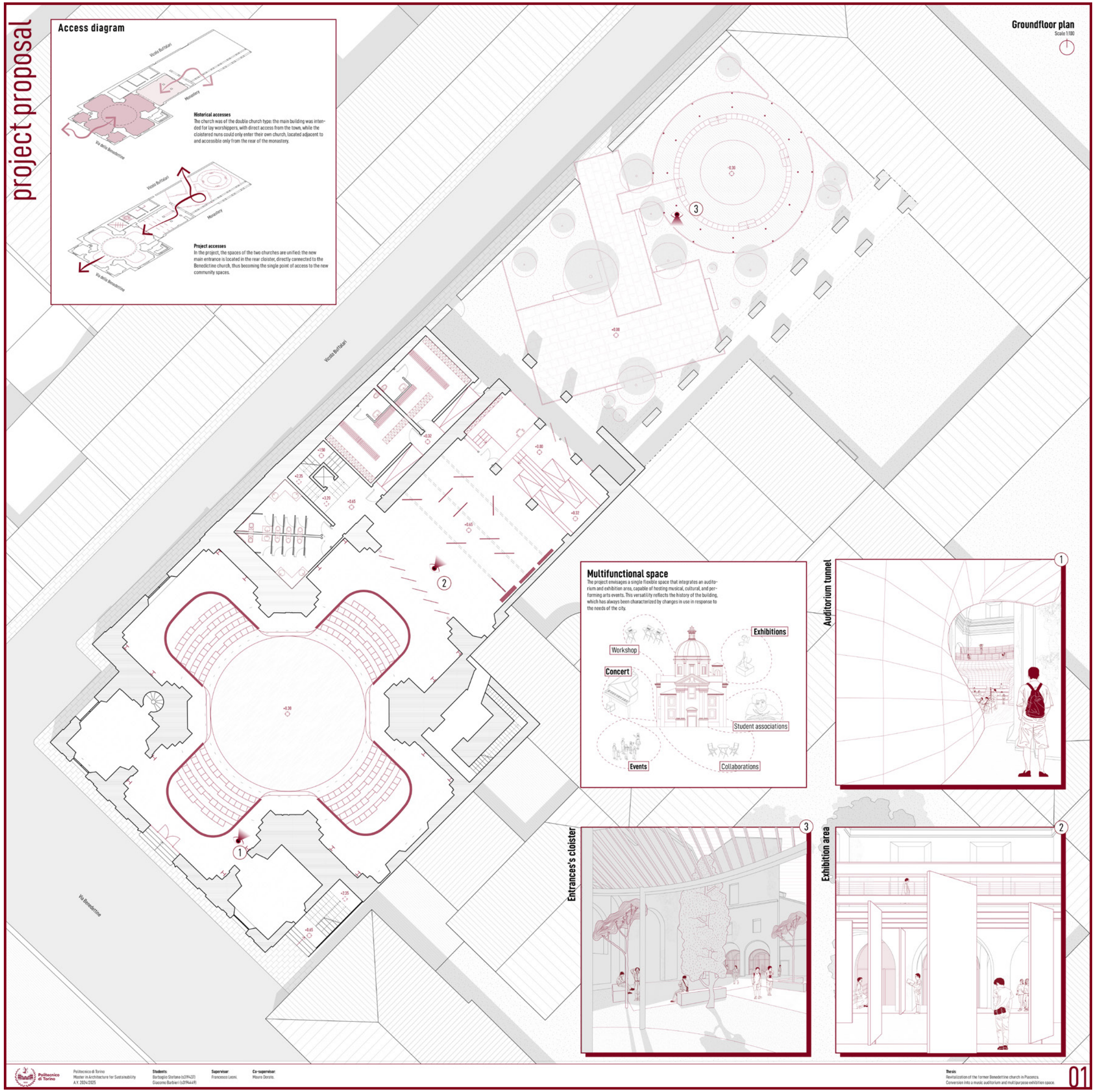
Politecnico di Torino
Master in Architecture for Sustainability
A.Y. 2024/2025

Students: Barbaglio Stefano (s319437), Giacomo Barbieri (s3194449)
Supervisor: Francesco Leoni.
Co-supervisor: Mauro Dorato.

Thesis: Revitalization of the former Benedettine church in Piacenza. Conversion into a music auditorium and multipurpose exhibition space.

00

BOARD 01



project proposal
Access diagram
Vicolo Buffalari
Monastery
Via delle Benedettine
Historical accesses
The church was of the double church type: the main building was intended for lay worshippers, with direct access from the town, while the cloistered nuns could only enter their own church, located adjacent to and accessible only from the rear of the monastery.
Project accesses
In the project, the spaces of the two churches are unified: the new main entrance is located in the rear cloister, directly connected to the Benedictine church, thus becoming the single point of access to the new community spaces.
Groundfloor plan
Scale 1:100
Multifunctional space
The project envisages a single flexible space that integrates an auditorium and exhibition area, capable of hosting musical, cultural, and performing arts events. This versatility reflects the history of the building, which has always been characterized by changes in use in response to the needs of the city.
Workshop
Exhibitions
Concert
Student associations
Events
Collaborations
Auditorium tunnel
Entrances's cloister
Exhibition area
Politecnico di Torino
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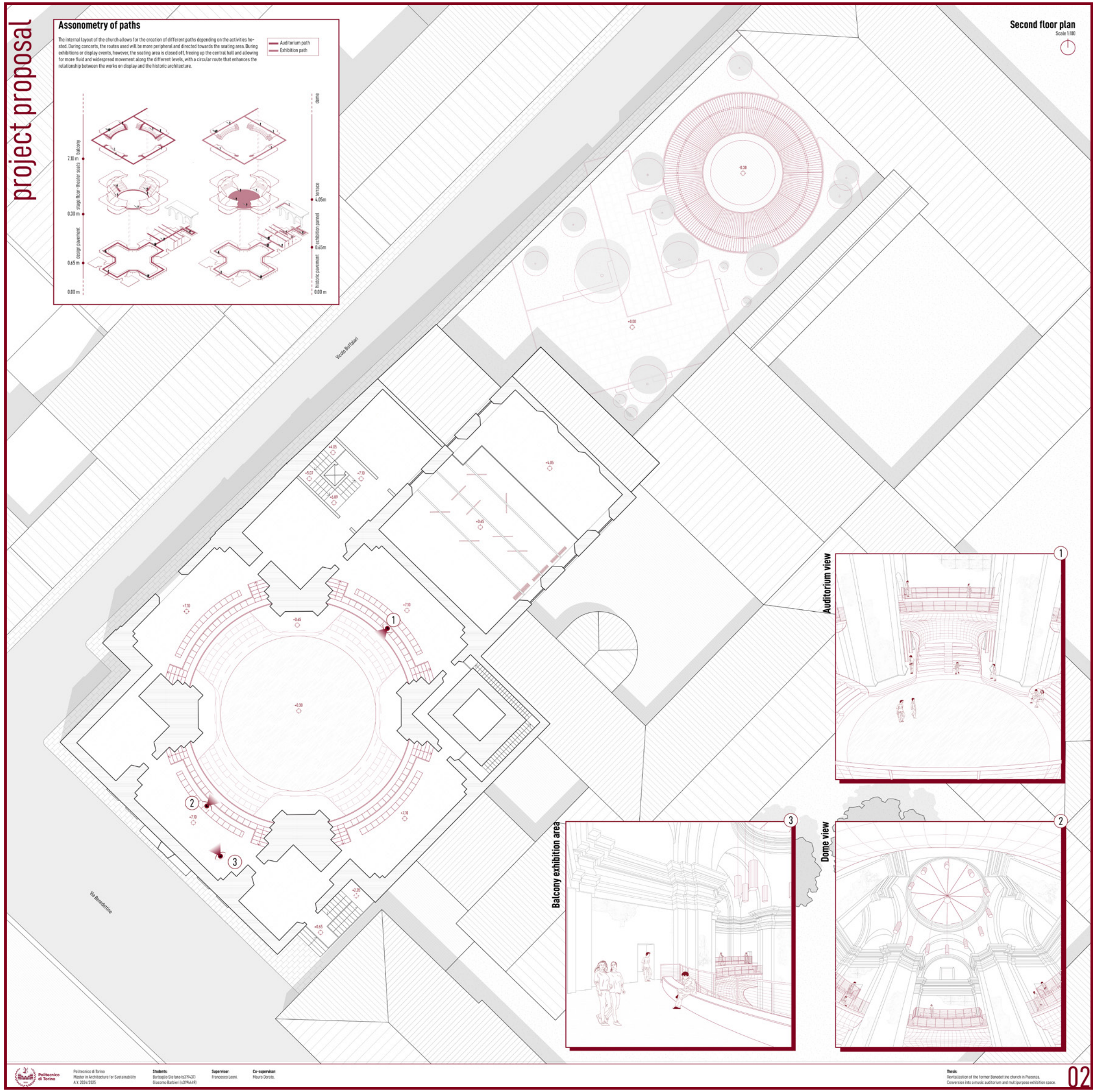
project proposal
Assonometry of paths
The internal layout of the church allows for the creation of different paths depending on the activities hosted. During concerts, the routes used will be more peripheral and directed towards the seating area. During exhibitions or display events, however, the seating area is closed off, freeing up the central hall and allowing for more fluid and widespread movement along the different levels, with a circular route that enhances the relationship between the works on display and the historic architecture.
Auditorium path
Exhibition path
dome
Second floor plan
Auditorium view
Dome view
Balcony exhibition area
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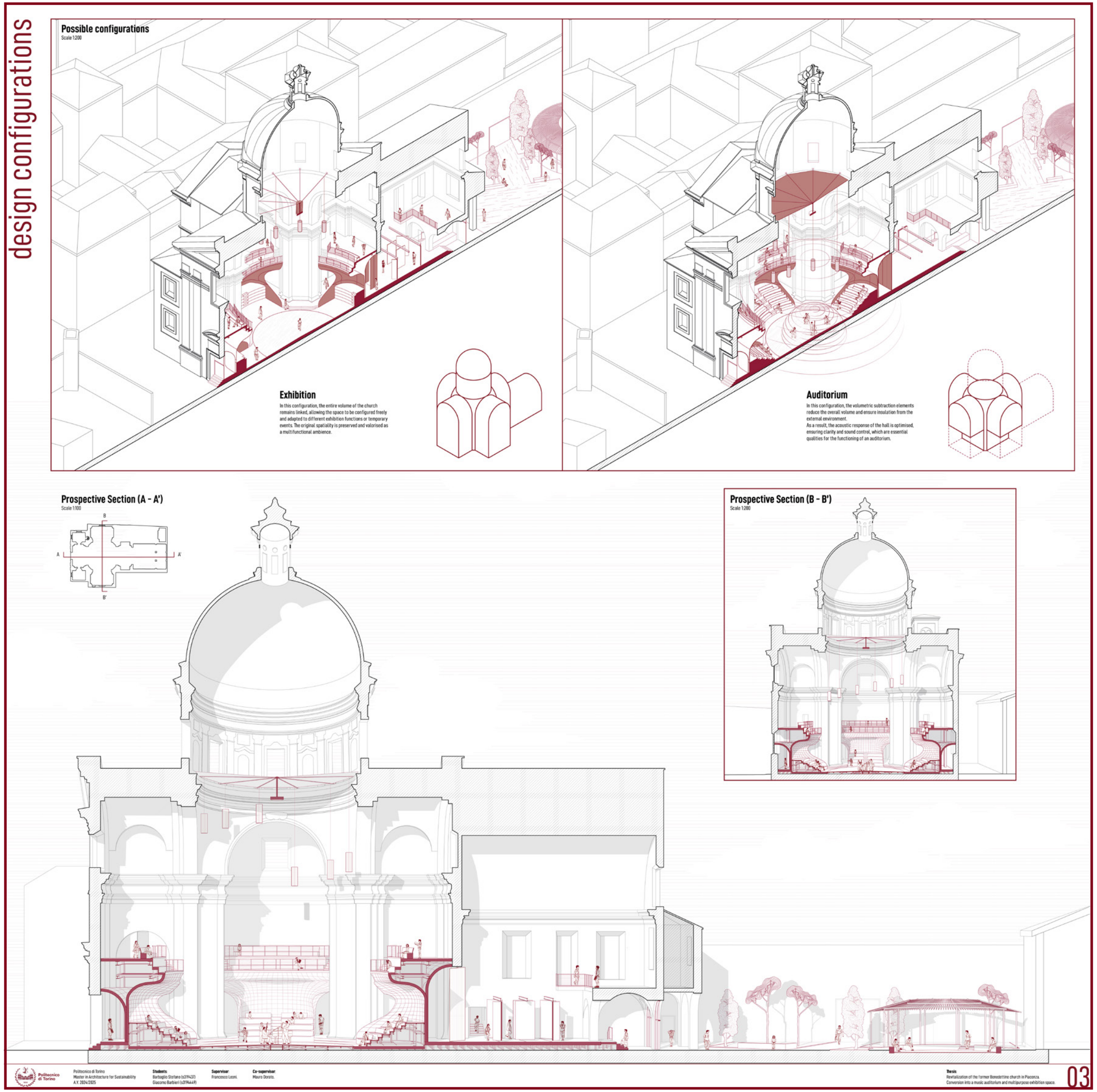
02

BOARD 03


design configurations
Possible configurations
Scale 1:200
Exhibition
In this configuration, the entire volume of the church remains linked, allowing the space to be configured freely and adapted to different exhibition functions or temporary events. The original spatiality is preserved and valorised as a multifunctional ambience.
Auditorium
In this configuration, the volumetric subtraction elements reduce the overall volume and ensure insulation from the external environment.
As a result, the acoustic response of the hall is optimised, ensuring clarity and sound control, which are essential qualities for the functioning of an auditorium.
Prospective Section (A - A')
Scale 1:100
Prospective Section (B - B')
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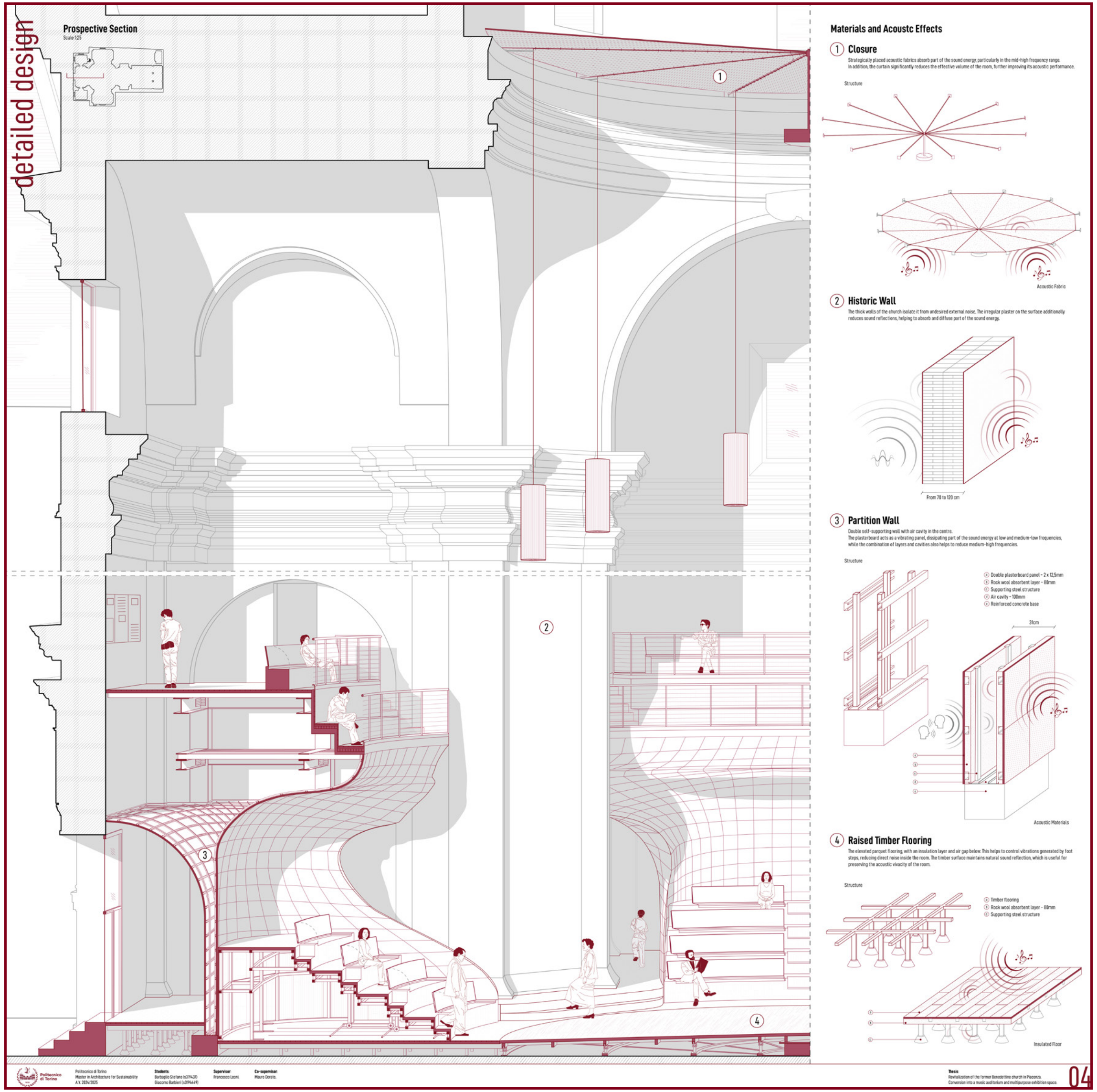
03


detailed design
Prospective Section
Scale 1:25
1
2
3
4
Materials and Acoustc Effects
1 Closure
Strategically placed acoustic fabrics absorb part of the sound energy, particularly in the mid-high frequency range.
In addition, the curtain significantly reduces the effective volume of the room, further improving its acoustic performance.
Structure
Acoustic Fabric
2 Historic Wall
The thick walls of the church isolate it from undesired external noise. The irregular plaster on the surface additionally reduces sound reflections, helping to absorb and diffuse part of the sound energy.
From 70 to 120 cm
3 Partition Wall
Double self-supporting wall with air cavity in the centre.
The plasterboard acts as a vibrating panel, dissipating part of the sound energy at low and medium-low frequencies, while the combination of layers and cavities also helps to reduce medium-high frequencies.
Structure
a Double plasterboard panel - 2 x 12,5mm
b Rock wool absorbent layer - 80mm
c Supporting steel structure
d Air cavity - 100mm
e Reinforced concrete base
31cm
Acoustic Materials
4 Raised Timber Flooring
The elevated parquet flooring, with an insulation layer and air gap below. This helps to control vibrations generated by foot steps, reducing direct noise inside the room. The timber surface maintains natural sound reflection, which is useful for preserving the acoustic vivacity of the room.
Structure
a Timber flooring
b Rock wool absorbent layer - 80mm
c Supporting steel structure
Insulated Floor
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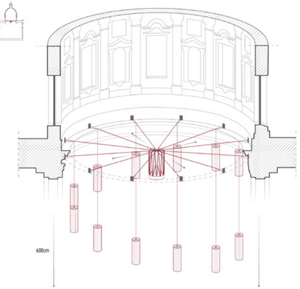
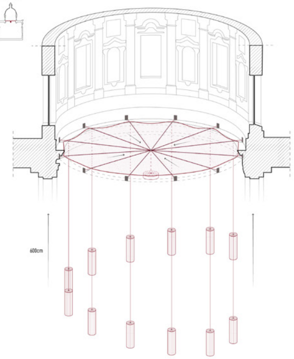
BOARD 05

elements

Dome Closure (open / closed)
Scale 1:200

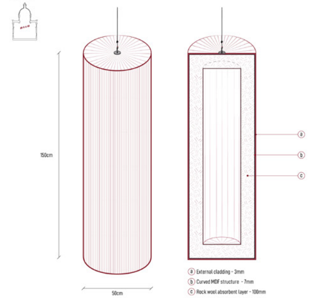


Dome Closure (open / closed)
Scale 1:100



Mobile acoustic element that closes the space beneath the dome to reduce room volume and enhance acoustics. It can be operated manually or motorized, using cylindrical bass traps as counterweights, allowing the dome to be opened or closed as needed.

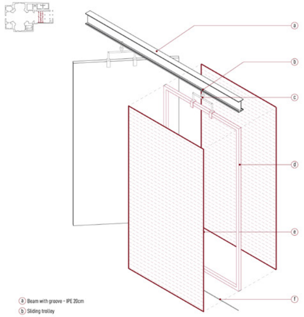
Bass Trap
Scale 1:10



- (a) External cladding - 3mm
- (b) Curved MDF structure - 7mm
- (c) Rock wool absorbent layer - 100mm

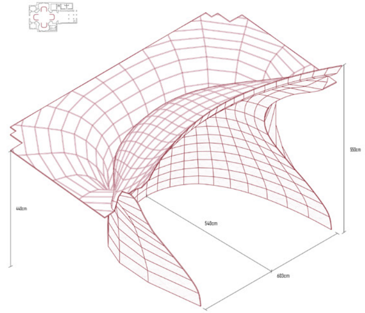
Acoustic device designed to reduce low-frequency accumulation and standing waves. its shape provides uniform absorption, improving clarity and balance in the ambient space.

Exhibition Panels
Scale 1:25



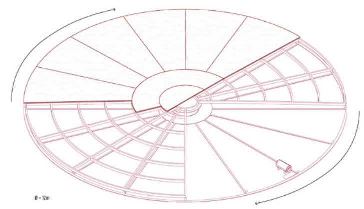
- (a) Beam with groove - IPE 20cm
- (b) Sliding trolley
- (c) Hanger with rotating bearing
- (a) Alluminium frame - 3cm
- (b) Cladding sheet - 0.2cm
- (c) Ground guide support

Sail Curve Structure
Scale 1:50



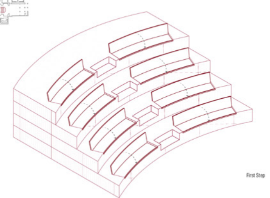
The double wall structure is self-supporting and performs both a distributive and acoustic function. Once assembled and panel-led, the structure reduces the volume of the room and helps to control the excessive propagation of unwanted frequencies.

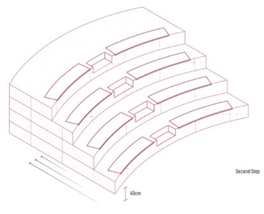
Turntable Stage
Scale 1:50

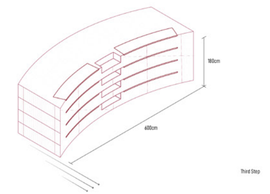


Circular platform assembled on a central pivot and powered by electric motors, allowing dynamic transformations of the stage and 360° interaction with the audience. It enables flexible configurations and engaging performances.

Folding Tiered Seating
Scale 1:50







Opened, it creates a tiered seating area for audiences or exhibitions.

Folding the backrest of the bench, the grandstands can also be used as exhibition space.

Closed, it folds up in a compact, space-saving design. Ideal for multifunctional setups.

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05

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03.2 – Technical Drawings and Views

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03.4 – Sabine Calculation: State of Project

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Image Index

01.2 – Ex-Church of the Benedictines

1. View of the Farnese axis on a historical map of Piacenza, highlighting the Benedictine Church, Palazzo Farnese and Palazzo Madama. Document held at the State Archives of Parma, no. 847.
2. Cadastral plan of the Benedictine monastery with its churches, public and private. Document held at the State Archives of Parma, no. 22/37b.
3. Plan by Domenico Valmagini. Document held at the State Archives of Parma, no. 22/37. Floor plan of the Benedictine Church in Piacenza.
4. Domenico Valmagini, 1681. Personal reworking based on the point cloud generated by the survey.
5. Habsburg cadastral map, 1822. Document held at the State Archives of Parma, P15 847 bis.

Watercolour depicting the Benedictine church and the square it overlooked, Giovanni Paolo Panini, 172. Document held at the State Archives of Parma, no. 22/9.

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2. Fondazione Teatri di Piacenza, scheda "Sala dei Teatini"; Comune di Piacenza, "Sala dei Teatini – Ex chiesa di San Vincenzo".
3. Scuola primaria "Caduti sul Lavoro" & progetto "Orchestra CinqueQuarti" (Piacenza)
4. PCTerzo Circolo, pagina del progetto "Cinque quarti" (laboratori orchestrali); articolo con galleria fotografica sul debutto dell'orchestra.
5. Museo del Violino – pagina ufficiale dell'Auditorium e pagina "Realizzazione"

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02.1 – Architectural Survey

1. Screen showing the sectioned point cloud. Screenshot taken from the Autodesk ReCap programme.
2. Screen showing the completei external point cloud. Screenshot taken from the Autodesk ReCap programme.
3. Screen showing the complete inner point cloud. Screenshot taken from the Autodesk ReCap programme.

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