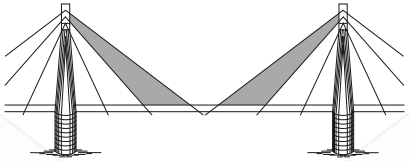
SM Ingegneria s.r.l.

Historical heritage



SM Ingegneria s.r.l.

Prof. Ing. Claudio Modena

SM Ingegneria s.r.l. was established in September 2001. The firm is based on previous professional experience, since 1990, of Eng. Claudio Modena, Full Professor of Structural Engineering at University of Padua. SM Ingegneria operates in the field of civil engineering dealing with road infrastructures, building and industrial structures, special structures and foundations. The firm is highly skilled in restoration of historic masonry buildings, seismic adjustment and consolidation of reinforced concrete buildings and bridges.

In these areas the engineering firm developed highly specialized technical and scientific aspects and advanced applications tools for structural analysis (e.g. theoretical-experimental methods of evaluation of structural efficiency of buildings and bridges) and constructive technologies (e.g. by using of the fibre-reinforced polymer both in monumental building and transport infrastructures).

Furthermore, SM Ingegneria has already worked for a wide range of clients and projects also cooperating with prestigious architectural studios like DCA (David Chipperfield Architects), AMDL (Architect Michele De Lucchi S.r.l.), Gae Aulenti Architetti Associati, Eduardo Souto de Moura Architects, Kleihues+Kleihues, Kollhoff Architekten, Mario Botta Architects.

CHAIRMAN AND DIRECTOR

Chairman and director of SM Ingegneria is Prof. Claudio Modena, born on June 12, 1946 in Sommacampagna (VR), Italy.

He graduated “summa cum laude” in Civil Engineering from the University of Padua (www.dicea.unipd.it) in 1970. He received a triennial Research Scholarship from the Ministry of Education and in 1974 he was appointed Assistant Professor of Structural Engineering at Padua University.

Prof. Claudio Modena, now Professor Emeritus, was Full Professor of Structural Engineering and director of the Material Testing Laboratory at the Department of Structural Engineering of University of Padua. He was also a Technical and Scientific Head of SIL – Integrated System of University and Independent Laboratories in Padua.

Since 2000 he has held the course of “Structural Problems of Monumental Historical Heritage” in Architectural and Building Engineering and the specializing course of “Historical Constructions Restoration” for Architects and Engineers

Since 2002 Prof. Claudio Modena has been a Postgraduate Master Course Director in:
Structural restoration of monuments and historic buildings
Infrastructure design with regard to the accomplishment of the territorial designs

Prof. Claudio Modena has been admitted into the Association of Engineers of Verona, Italy, with no. 830, since 11/03/71. He is also a registered technical tester specialist for constructions, bridges, buildings and special structures.

WORKING TEAM

Chairman
Claudio Modena

Project leaders
Carlo Bettio, Federico Reginato, Mirko Stoppa

Construction site assistant/Designer
Francesca Lucchin, Massimiliano Mesaroli, Marco Mocellini, Alessio Perlini, Elena Simonato, Emanuele Terrini

Designer
Alessandra Aldegheri, Alice Bartolozzi, Elvis Cescatti, Nicola De Conto, Gianluca Iraci Sareri, Enrico Manfrin, Manuel Marotto, Nicola Prodomi, Stefano Signorini

Construction site assistant
Stefano Filippini, Daniela Ravagnin, Edoardo Xodo

Graphic designer
Andrea Formigoni

Graphic & BIM external consultant
Marco Pastorino

Administrative area
Maina Dal Bosco, Martina Perusi

CHURCHES - RELIGIOUS BUILDINGS

FORTIFIED CITADELS

CIVIC AND BELL TOWERS

PALACES

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT

TECHNOLOGICAL SOLUTIONS FOR ARTISTIC OBJECTS

BRIDGES

ARCHAEOLOGICAL SITES

POST SEISMIC REPAIR AND STRENGTHENING INTERVENTIONS

CHURCHES - RELIGIOUS BUILDINGS

CHURCHES - RELIGIOUS BUILDINGS

CHURCHES AND RELIGIOUS BUILDINGS

- Restoration of the Holy Crown's Church, Vicenza (Italy) 2006-2012
- Structural reinforcement of the pillars of St. Sofia's Church, Padova (Italy) 2007-2010
- Short term countermeasures of the church of S. Benedetto, damaged by the earthquake of 30.10.2016, Norcia (Italy), 2017-2018
- Seismic assessment and retrofit and structural reinforcement of the Upper Room and the tomb of David in Jerusalem (Israel)
- Preliminary examination of the state of consistency and damage of the structures of the Holy Sepulcher in Jerusalem (Israel)
- Restoration of the Reggio Emilia Cathedral (Italy)
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- Restoration of the Verona Cathedral (Italy)
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- Restoration and structural reinforcement of the roofs of St. Giustina's Abbey, Padova (Italy)
- Restoration of St. Maria in Organo Church, Verona (Italy)
- Restoration of St. Zeno's Church, Verona (Italy)
- Restoration of the frescoed vault of St. Antonio Church's library, Padova (Italy)
- Restoration of St. Lorenzo's Church, Verona (Italy)
- Restoration of the Praglia abbey cloisters, Padova (Italy)
- Restoration and structural reinforcement of St. Maria del Torresino's Church, Padova (Italy)
- Structural diagnostics and design of structural reinforcements of the columns of the San Vigilio's Cathedral, Trento (Italy)
- Seismic analysis of the Parish Church of Saints Peter and Paul, Marano di Valpolicella (Verona, Italy)
- Structural reinforcement of St. Stefano Church, Monselice (Padova, Italy)
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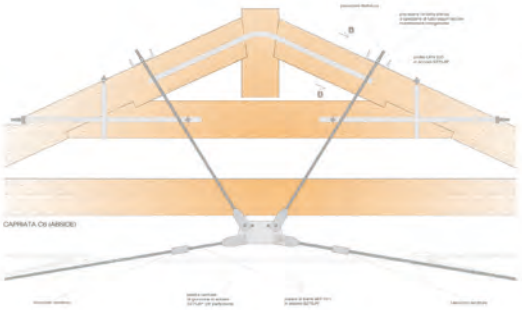
- Reparation after earthquake of the Saints Peter and Paul Cathedral, Villafranca Veronese (Verona, Italy)
- Urgent structural reinforcement of the chapel in Villa Beggiato, Grisignano (Vicenza, Italy)
- Restoration of the Old Choir in the Santa Giustina Abbey, Padova (Italy)

Restoration of the Holy Crown's Church, Vicenza (Italy) 2006-2012

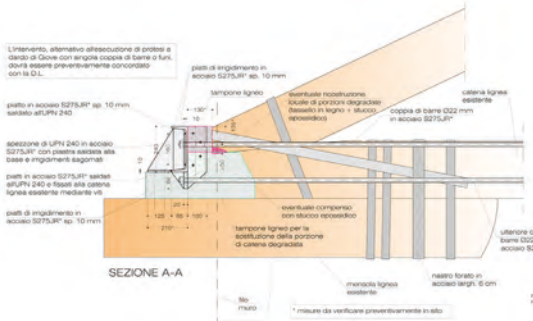
Preliminary, final, detailed design and supervision of works
Total construction cost: € 6,39 million

The church was built in 1260 in the Vicenza city centre to host the thorn relic of Jesus' crown. Since the 1303 was a court of the medieval inquisition and after it hosts tombs of influential people of the city. Also some chapels were built by important families as Valmarana's chapel designed in 1576 by Andrea Palladio.
The intervention concerns the restoration of all the surfaces and the decorative paintings both in the internal and external parts, the rehabilitation of distributive and functional spaces connected to the church and the replacement of all technical plants. From a structural point of view, a large and diffuse series of interventions has been done with two aims: the first was the local consolidation of damages and degradations sprawl over the church and the second was the improvement of the seismic behaviour achieved by retrofitting interventions.
The techniques were both traditional and innovative. The latter regards the use of FRP and stainless reinforcements. The repairing of cracks with 'scuci-cuci' technique by brick and mortar made with hydraulic lime and the recover, or when necessary the substitution, of damaged timber elements was designed and accomplished according the strictest restoration guidelines and criterions. Those interventions have been studied to have an high durability and they were as much reversible and simply as possible.

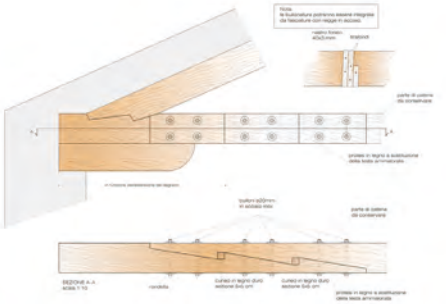
Consolidation of timber truss with steel ties

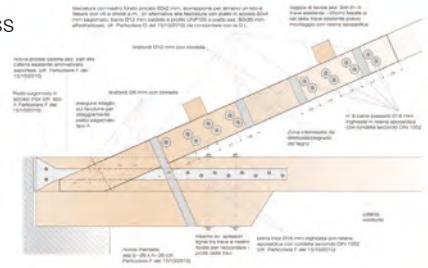


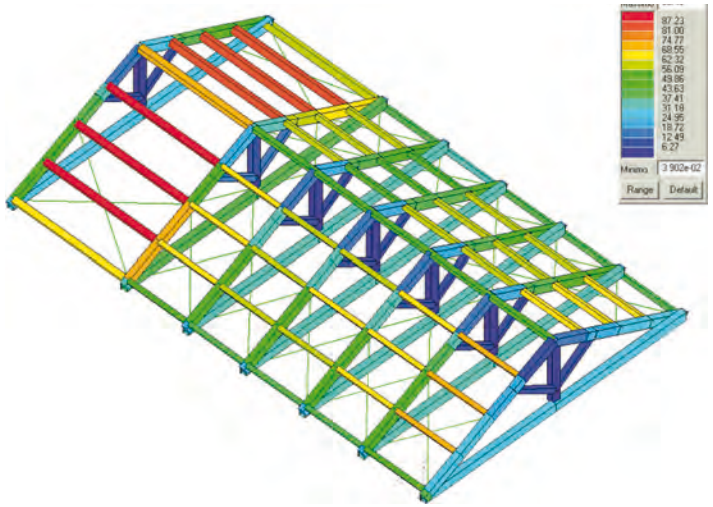
Restoring the deteriorated head of the timber chain



Reinforcing of the deteriorated head of the timber truss



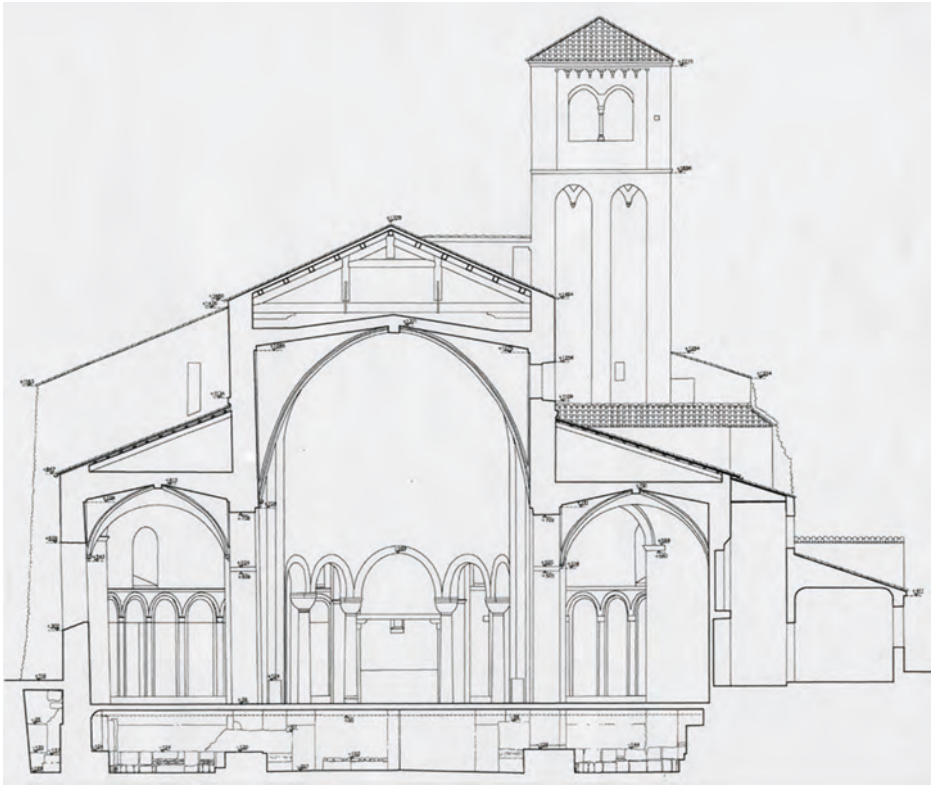


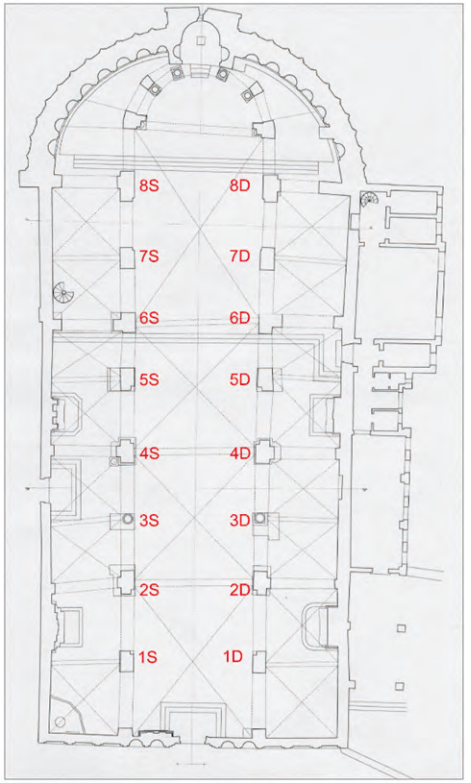


Structural reinforcement of the pillars of St. Sofia's Church, Padova (Italy) 2007-2010

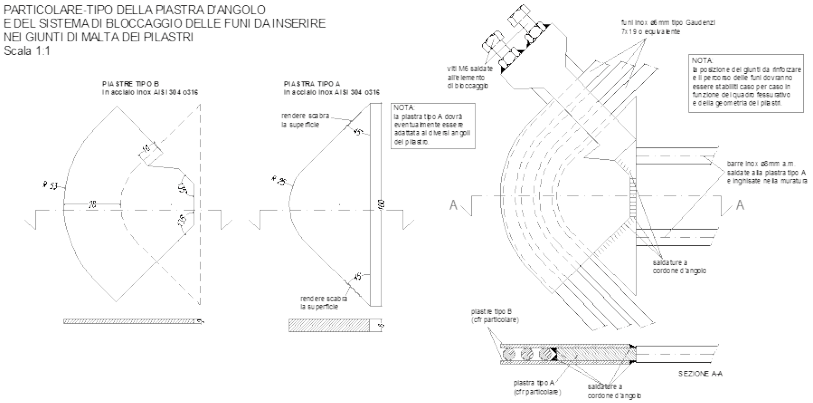
Design and supervision of works
Total construction cost (I and II phase): € 400.000

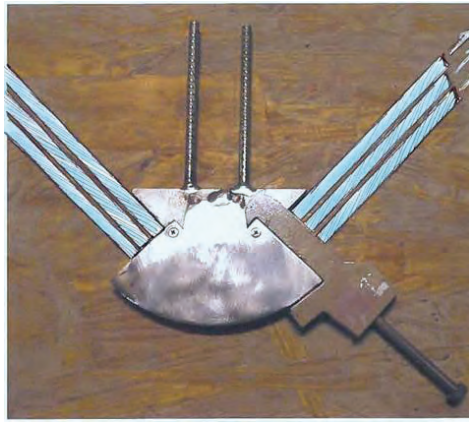
The Santa Sofia's church is one of the ancient church in Padova, it was built in the roman period on the remains of an existing place of worship. The reconstruction phase began from the apse between the 1106 and the 1110 and completed in 1127.
The church has pillars to divide the nave from and two aisles on which are based the masonry groin vaults. During the past centuries those vertical element were already matter of some interventions. The design and the execution of the interventions were divided in two phases (2007/08-2009/10)also with a control phase by a structural health monitoring (held by the Department of Constructions and Transport of the University of Padova) in both dynamic and static field.
The consolidation was based on the confinement improvement of masonry by means of deflectors and stainless ropes with a diameter of 6 mm for the diffuse strengthening and of 12 mm for the replacement of the existing hooping reinforcement. The designed hooping system is 'active' (due to the pre-tension) and located in mortar joints thus today those reinforcements are completely hidden.

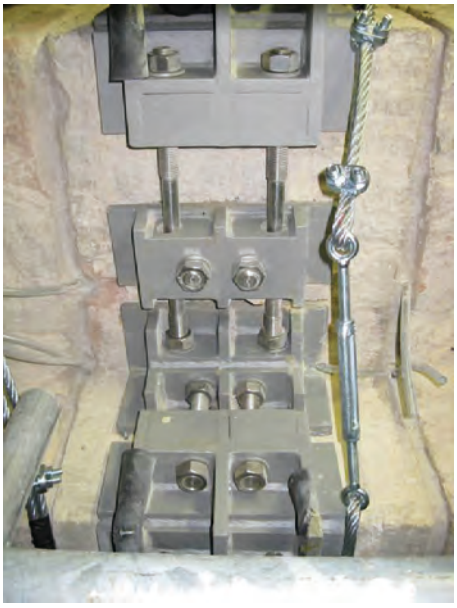




PARTICOLARE-TIPO DELLA PIASTRA D'ANGOLO
E DEL SISTEMA DI BLOCCAGGIO DELLE FUNI DA INSERIRE
NEI GIUNTI DI MALTA DEI PILASTRI
Scala 1:1







Short term countermeasures for S. Benedetto church, Norcia (Perugia, Italia), 2017-2018

Final and detailed design;
Supervision of works

Following the seismic event of 30 October 2016, the church of S. Benedetto in Norcia suffered serious damage and extensive collapses, leaving the facade, a portion of the gothic portal, the apse and remains of the bell tower and of the transept unsafe.

The short term countermeasures for the facade were carried out in several phases, taking into account the various situations and risks involved; the design involved the construction of a tube-joint scaffolfingto hold the façade in both directions. To avoid the exposure of the operators during the assembly phase, the scaffolding was made in a safe position in Piazza S. Benedetto to be subsequently positioned by a mobile crane (part A). Once these parts have been installed that prevent the overturning of the façade towards the square, the ballast have been put in place and the rear containment beam has been realized, in order to avoid the overturning towards the inside of the church.

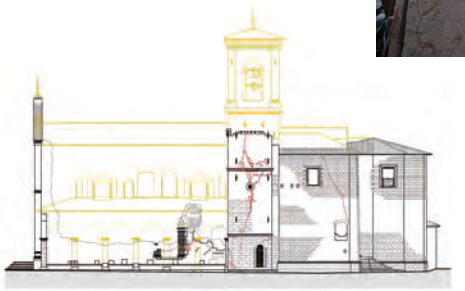
In the remaining portion of the bell tower, considering the craking mechanisms uncovered, two shoring systemswere realized to prevent the overturning and the base sliding of the entire cracked portion of the bell tower. A second tube-joint structure scaffolding ensures the stability of the portal.

For the apse and the right transept the safety intervention consists of the construction of an external scaffolding with some connections with the interior, passed through the windows to “confine” the masonry, strongly broken up inside.

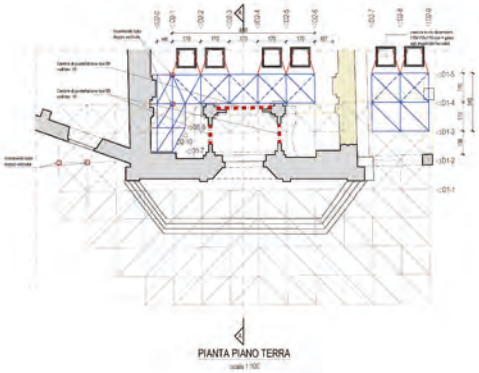
With regard to the coverage of the left transept, it was not possible to operate with propping structures resting inside the church due to the presence of the rubble; the entire floor was disassembled joist by joist.

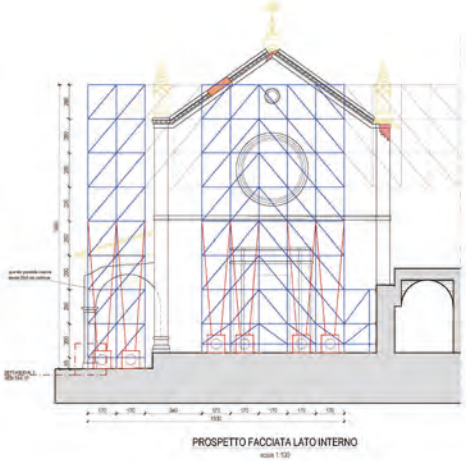
SEZIONE LONGITUDINALE A-A

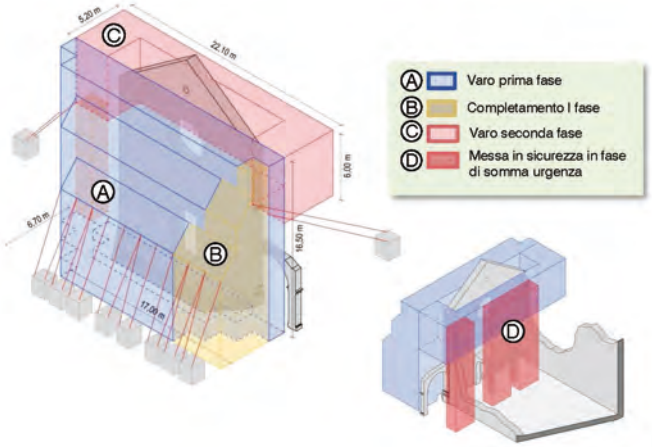
PROSPETTO PRINCIPALE SU VIA REGUARDATI E PIAZZA SAN BENDETTO

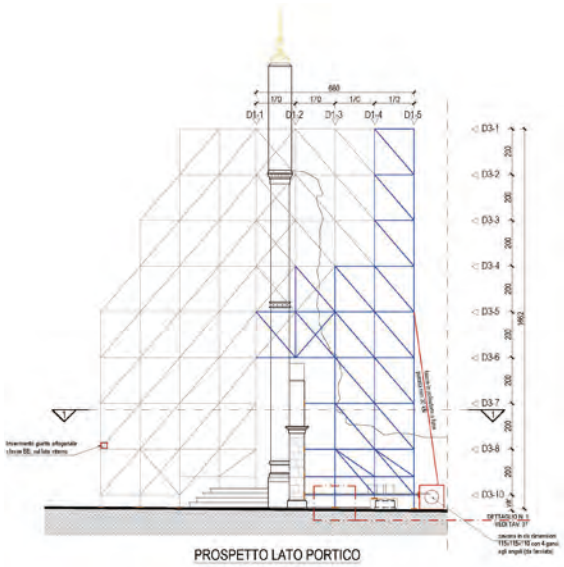


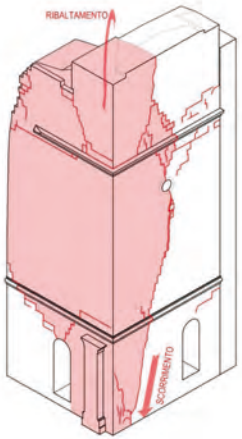
PROSPETTO LATERALE SU VIA MAZZINI

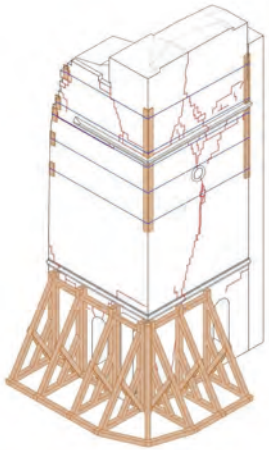

PIANTA PIANO TERRA

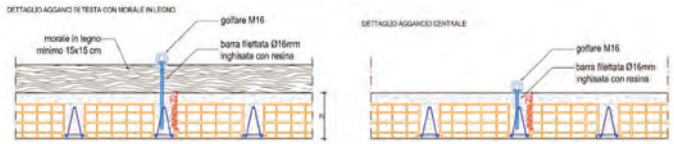

PROSPETTO FACCIATA LATO INTERNO


A Varo prima fase
B Completamento I fase
C Varo seconda fase
D Messa in sicurezza in fase di somma urgenza


PROSPETTO LATO PORTICO


RIBALTAMENTO
SCORRIMENTO




DETTAGLIO AGGANCI DI TESTA CON MORALE IN LEGNO
golfare M16
morale in legno
minimo 15x15 cm
barra filettata Ø16mm
inghisata con resina
DETTAGLIO AGGANCIO CENTRALE
golfare M16
barra filettata Ø16mm
inghisata con resina

Seismic assessment and retrofit and structural reinforcement of the Upper Room and the tomb of David in Jerusalem (Israel)

Preliminary examination of the state of consistency and damage of the structures of the Holy Sepulcher in Jerusalem (Israel)

Restoration of the St. Fermo's Church, Verona (Italy)

Restoration of the Verona Cathedral (Italy)

Restoration and structural reinforcement of the St. Peter's Church, Onna (L'Aquila, Italy)

Restoration and structural reinforcement of the roofs of St. Giustina's Abbey, Padova (Italy)

Restoration of the Reggio Emilia Cathedral (Italy)

Restoration of the St. Zeno's Church, Verona (Italy)

Structural diagnostics and seismic assessment of San Biagio's Temple in Montepulciano (Siena, Italy)

Restoration of the frescoed vault of the St. Antonio Church's library, Padova (Italy)

Restoration of the St. Lorenzo's Church, Verona (Italy)

Restoration of the Praglia abbey cloisters, Padova (Italy)

Restoration and structural reinforcement of the St. Maria del Torresino's Church, Padova (Italy)

Structural diagnostics and design of structural reinforcements of the columns of the San Vigilio's Cathedral, Trento (Italy)

Seismic analysis of the Paris Church of Saints Peter and Paoul, Marano di Valpolicella (Verona, Italy)

Structural reinforcement of St. Stefano Church, Monselice (Padova, Italy)

Urgent structural reinforcement of the San Francisco del Baron Church, Valparaiso (Chile)

Restoration of St. Lucia and Vittore Church in Biadene, Montebelluna (Treviso, Italy)

Restauro della Chiesa di Santa Maria in Organo, Verona (Italia)

Restoration and structural reinforcement of the St. Maria Assunta's Church, Volterra (Pisa, Italy)

Urgent structural reinforcement of the chapel in Villa Beggiato, Grisignano (Vicenza, Italy)

Restoration of the former St. Michele Church, Golasecca (Varese, Italy)

Reparation after earthquake of the Saints Peter and Paoul Cathedral, Villafranca Veronese (Verona, Italy)

Restoration of the Old Choir in the Santa Giustina Abbey, Padova (Italy)

FORTIFIED CITADELS

FORTIFIED CITADELS

- Static consolidation and reinforcement of the Cittadella walls, Cittadella (Padova, Italy), 2002-2006
- Structural restoration of the Venice's Arsenal, Venezia (Italy), 2001-2009
- Structural consolidation as part of the restoration of the fortified walls of Montagnana, Padova (Italy)
- Structural reinforcement and restoration of the North-East wing of the sixteenth-century castle which was heavily damaged during 2009 earthquake, L'Aquila (Italy)
- Structural restoration of ramparts and fortified walls of Padua (Italy)
- Restoration and renovation of the Former Habsburg barracks named S. Peter Castle, Verona, (Italy)
- Restoration of Fienga Castel, Nocera Inferiore (Italy)
- Preliminary structural design for the new cultural area "Arsenale 2000" within the former Habsburg Arsenal, Verona (Italy)
- Restoration of Siracusa Castle, named "Maniace", Siracusa (Italy)
- Static consolidation and surveys programme of Marostica lower Castle, Vicenza (Italy)
- Consolidation of the walls of the Este castle, Padova (Italy)

Static consolidation and reinforcement of the Cittadella walls, Cittadella (Padova, Italy), 2002-2006

Detailed structural design
Total construction cost: € 1 million

Cittadella is one of the most important and well conserved walled town in Italy. The historical city centre is enclosed by a great surrounding wall which was built around the 1200 a.D. with an almost elliptical shape.
There are four robust entrances and along the wall and there are also towers of two different sizes called 'torri' and 'torresini'.
There was a diffuse degradation due to aggression of the ambient environment and also severe damages and settlements caused by manipulations of the foundation system.
In some zones those manipulations of the original embankments presented huge differences in levels between inside and outside with a dangerous reduction of the soil over the foundation system. Those situations have modified the initial equilibrium condition. Some parts showed considerable out of plane displacements that required urgent safety interventions performed with active system to avoid the wall overlap.
The strengthening interventions were designed one by one due to the different situations in which they were. The solutions were: driven piles, active supporting systems by means of hydraulic jacks, active stainless ties anchored to micropiles systems properly detached to the ancient foundations. All solutions has been design to be removable in order to guarantee reversibility.

Structural restoration of the Venice's Arsenal, Venezia (Italy), 2001-2009

Structural design, supervision, structural testing
Total construction cost: € 7 millions

The Venice's armory, built from 1150 to 1200, covers a very large area enclosed by walls. The structures covered by intervention are essentially buildings of "New Arsenal", artifacts built from 1400 to 1500 around a new dock. The buildings, after years of almost total neglect, presented themselves in a very bad state of preservation and required urgent action for the safety.
The buildings, named "tezoni delle galeazze", were in fact covered shipyards for the construction of a particular type of combat ship. It is load-bearing masonry buildings with roofs made from massive timber trusses made in '500. The intervention was aimed primarily at the conservation of hedges that due to the serious degradation were already partially collapsed.
Other buildings, objects of intervention, are sheds said the foundry buildings consist of more recent construction with masonry walls, stone pillars and roofs made both in mixed wood-steel (i.e. Polonceau type) and industrial metal structures jointed by hot riveting. The covering structures were in poor storage conditions for the rotting of wood joined to severe oxidation of the metallic elements caused by the marine environment.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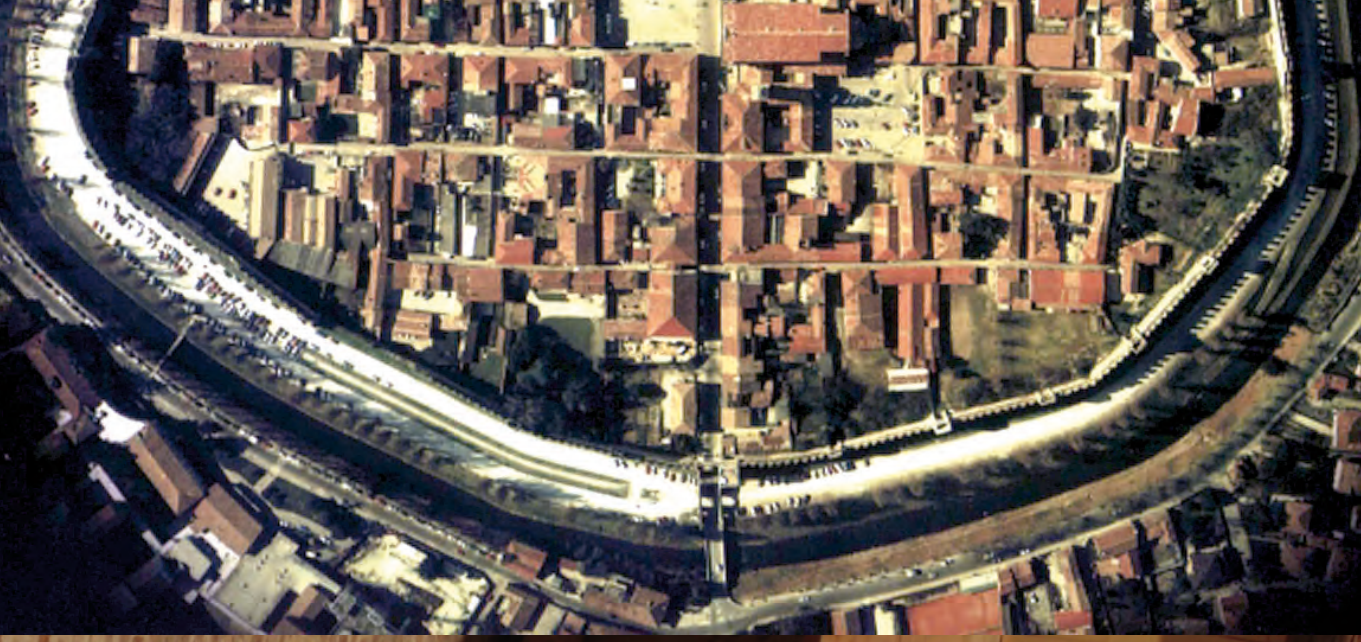

Structural consolidation as part of the restoration of the fortified walls of Montagnana, Padova (Italy)

Structural reinforcement and restoration of the North-East wing of the sixteenth-century castle which was heavily damaged during 2009 earthquake, L'Aquila (Italy)

Structural restoration of ramparts and fortified walls of Padua (Italy)

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Static consolidation and surveys programme of Marostica lower Castle, Vicenza (Italy)

CIVIC AND BELL TOWERS

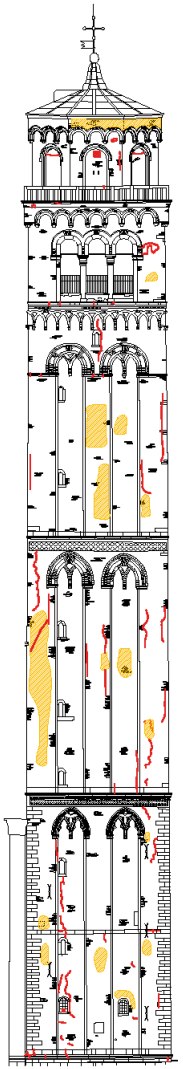
CIVIC AND BELL TOWERS

- Structural reinforcement of the Bell tower of “Frari” Church, Venezia (Italy)
- Restoration and structural reinforcement of the “Bissara” Tower also called square tower, Vicenza (Italy), 2000-2002
- Restoration and structural reinforcement of the Bell tower of St. Eufemia’s Church, Padova (Italy)
- Diagnostics and structural analysis of the Bell tower of St. Stefano’s Church, Venezia (Italy)
- Restoration and structural reinforcement of the Bell tower of St. Zeno’s Church, Verona (Italy)
- Restoration and structural reinforcement of the Bell tower of St. Giustina’s Church, Padova (Italy)
- Restoration and structural reinforcement of the Bell tower of Holy Crown Church, Vicenza (Italy)
- Restoration and structural reinforcement of the Bell tower of St. Domenico’s Church, Vicenza (Italy)
- Restoration and seismic analysis of the oblique Bell tower in Burano Island, Venezia (Italy)
- Static restoration and seismic improvement of the San Romedio bell tower at the Basilica of San Vigilio, Trento (Italy)
- Restoration and structural reinforcement of the Bell tower of Vangadizza Abbey, Badia Polesine (Rovigo, Italia)
- Restoration and structural reinforcement of the Clock Tower, Padova (Italy)
- Restoration and structural reinforcement of the Bell Tower of Monza Cathedral, Monza (Italy)
- Restoration and seismic improvement of the Bell tower of San Floriano’s Parish Church, Verona (Italy)
- Restoration and structural reinforcement of Vanga Tower, Trento (Italy)
- Restoration and structural reinforcement of the Bell tower of St. Tommaso’s Church, Verona (Italy)
- Restoration and structural reinforcement of the Bell tower of St. Marco’s Church, Pordenone (Italy)

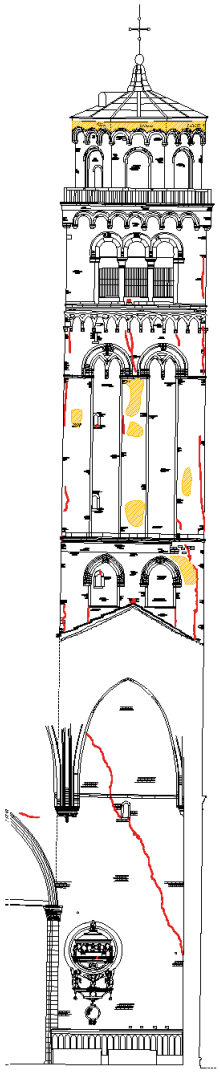
3.1 Structural reinforcement of the Bell tower of "Frari" Church, Venezia (Italy), 2008

Structural consulting
Total construction cost: € 1 million

The "latest" S. Maria Gloriosa dei Frari basilica was built in Venice between the first half of the XIV and the second half of XV century in gothic style. From the end of the construction the building suffered structural deterioration mainly due to settlements affecting the bell-tower. At the end of the 19th and at the beginning of the 20th century the church underwent major repairs because of the increasing sinking and leaning of the bell-tower, causing worrying damages on the basilica adjacent structures. During the 20th century the bell-tower still suffered from differential settlements; the early 900's foundation strengthening did not stop the tower to settle. The understanding of the behaviour of the structure was figured out by means of several specific tests and by a continuous structural health monitoring (SHM) before, during and after the interventions. Also the finite element models were calibrated on the tests results as the single and double flat jacket test. Many tests were performed also on soil to better understand the measured settlement.
The evidence of a rotating trend, which completely change after the foundation strengthening suggests problems on the foundations stress and stiffness. The interventions were mainly two. The first was localized on strengthening the foundations by the addition of micropiles. The second was located inside the church on the stresses distribution where it was added a new ties system to prevent overlap and where it was cut the link between the bell tower and the arch of the aisle. The SHM shows that the situation after interventions became more safety and stable.
This case provides the usefulness of experimental investigations and of detailed structural analysis.



SOUTH-EAST ELEVATION

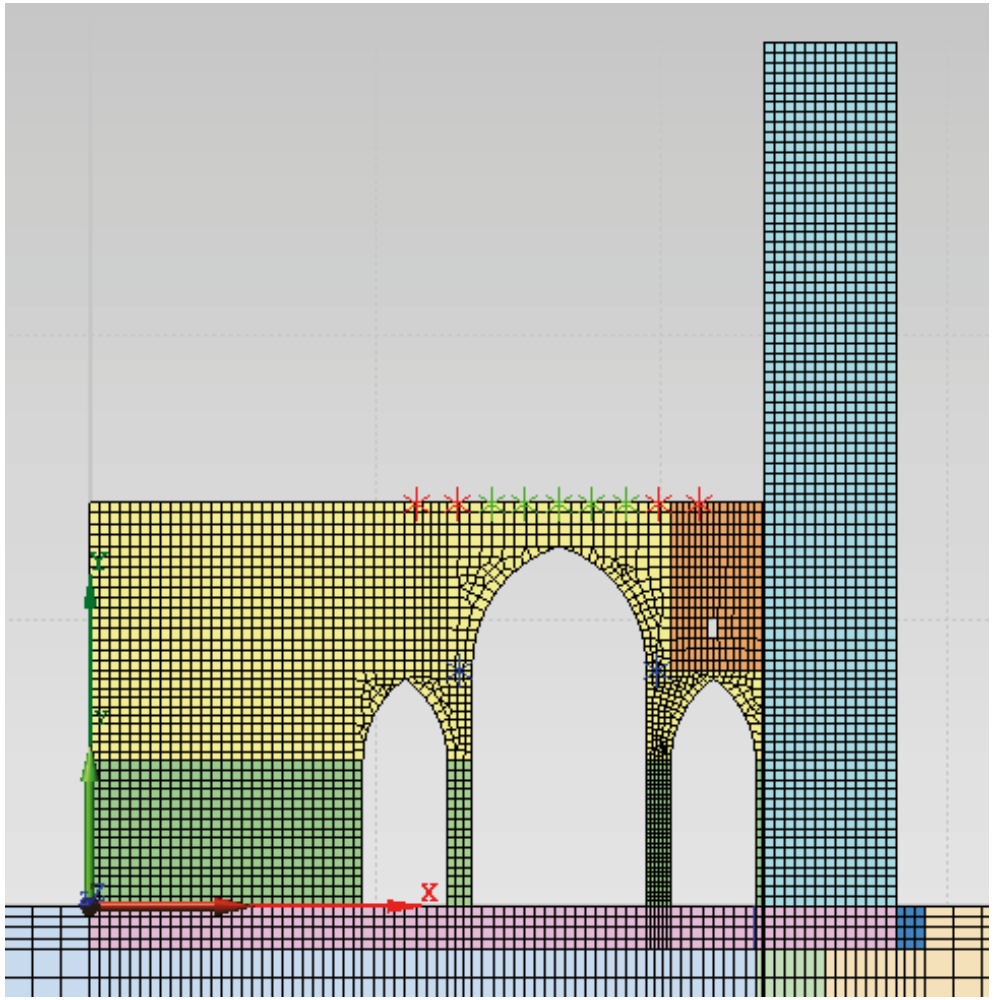


SOUTH-WEST ELEVATION

LEGEND

Cracks

Detachments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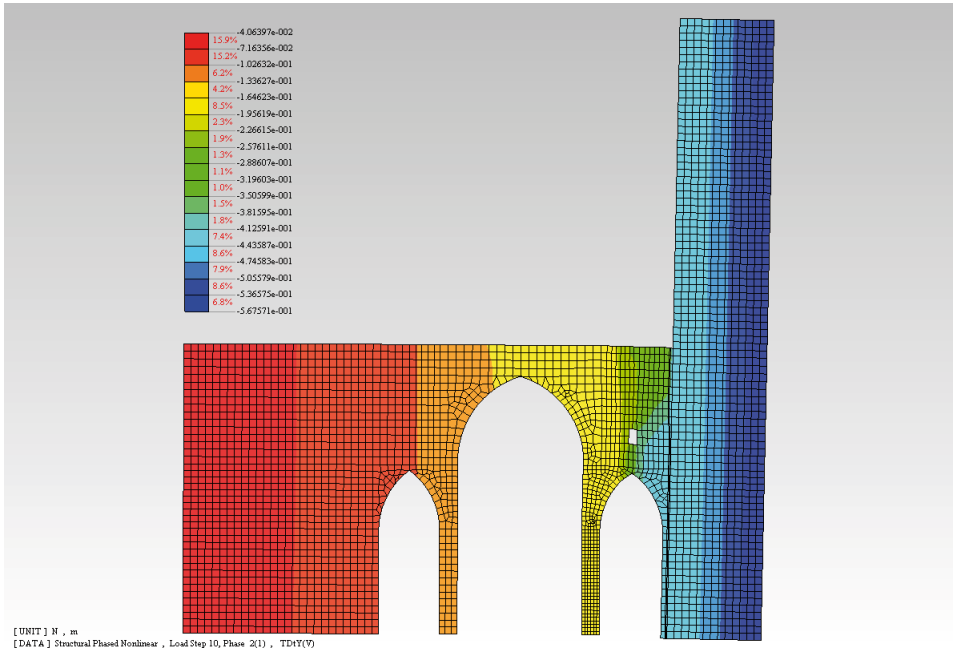
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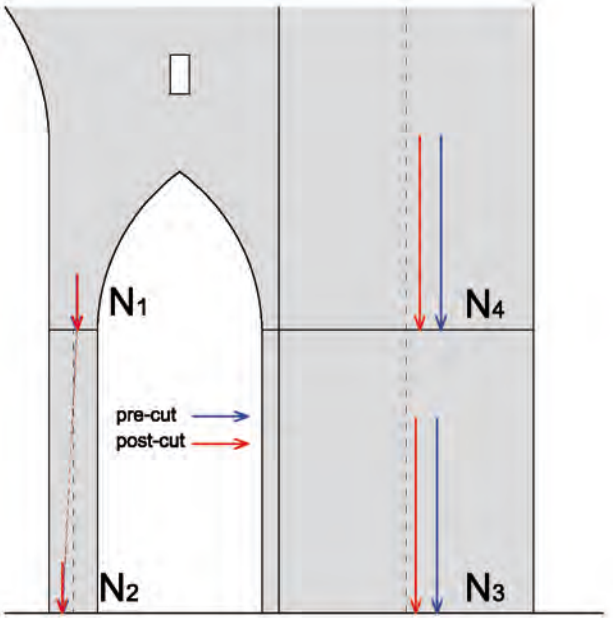
N1
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E1
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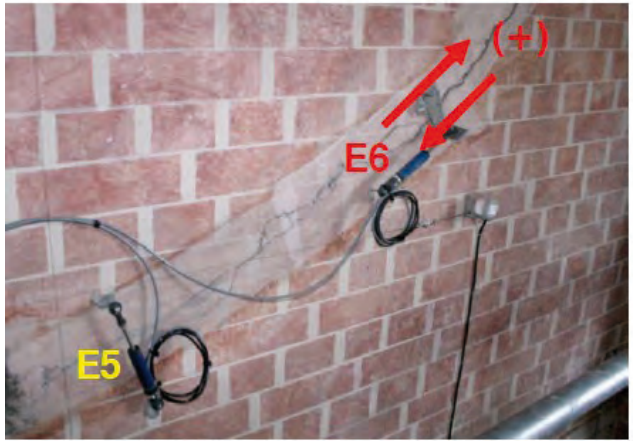
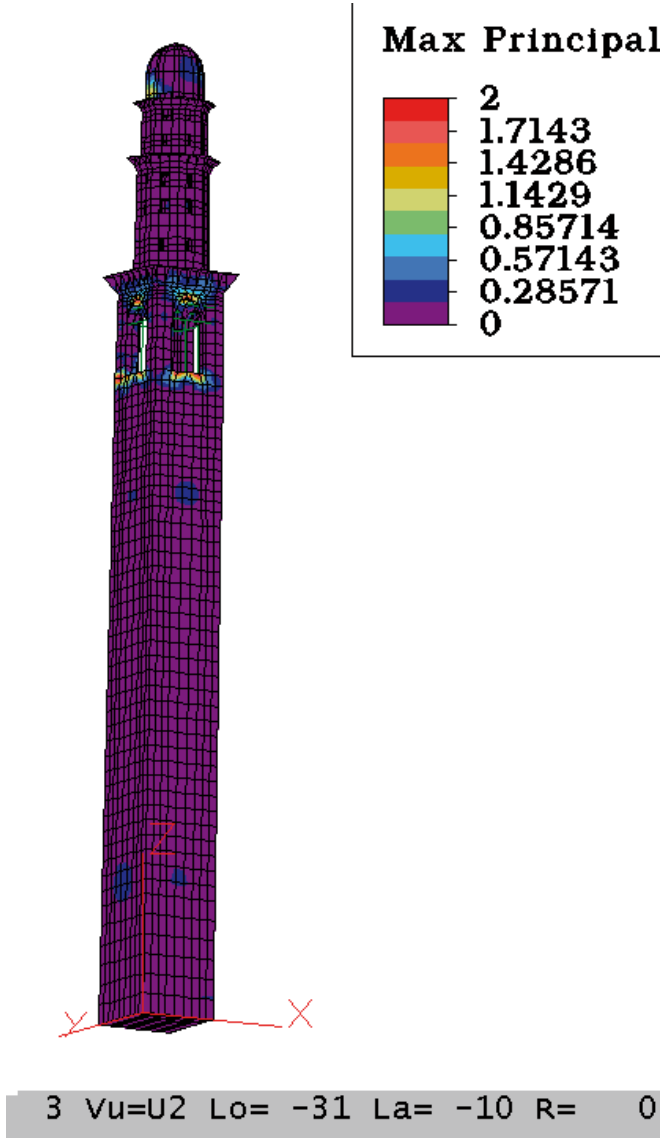

(+)
E6
E5

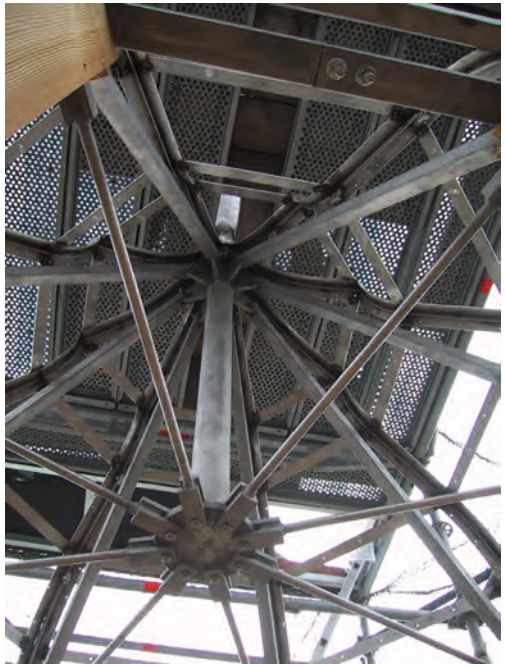

(+)
E8
E7

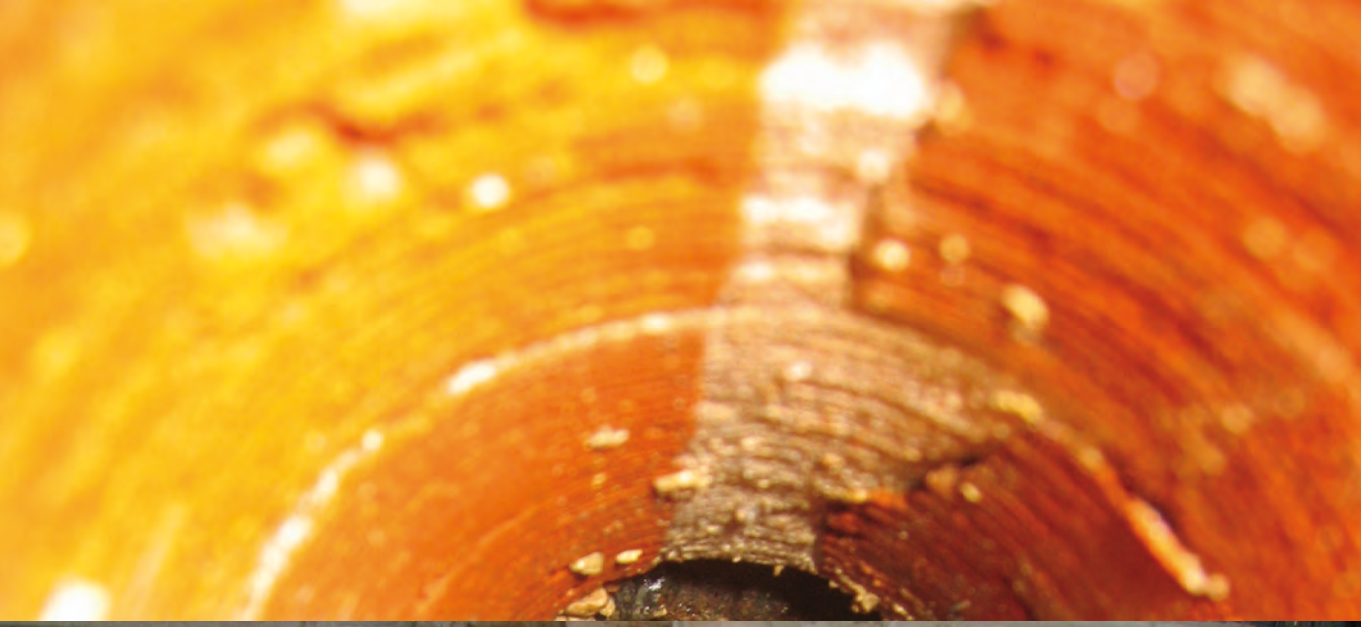
Restoration and structural reinforcement of the “Bissara” Tower also called square tower, Vicenza (Italy), 2000-2002

Detailed structural design for static consolidation and supervision of works
Total construction cost: € 1 million
Structures construction cost: € 800’000

The tower of “Piazza dei Signori” is made by a very slender masonry stem with the base section of about 6.2 x 6.5 meters and an overall height of approximately 83 meters. The tower has a significant slope in the north-west, which leads to the formation of significant concentrations of effort in areas under slope, as confirmed by experimental investigations carried out by flat jacks technique.
The consolidation, which covered the elevation, provided the confinement of the masonry through hoops of stainless steel, the consolidation of the most stressed parts by injection and the seam of the lesions using the “scuci-cuci” technique integrated with reinforced repoiting. The high octagonal drum was braced by exploiting the reconstruction of the interior timber decks.
Inspections conducted after the installation of scaffolding also showed severe degradation of the top part. The stability of the metal structure of the dome, that was rebuilt after the war as a result of damage caused by the bombing, was compromised by oxidation: it was then decided the makeover with a new structure consisting of curved ribs of larch wood and a steel frame steel.
In addition to the structural consolidation the work has included the restoration of the brick surfaces, restoration of the clock, and sculptural groups of frames and stone elements.







Restoration and structural reinforcement of the Bell tower of St. Eufemia's Church, Padova (Italy)

Diagnostics and structural analysis of the Bell tower of St. Stefano's Church, Venezia (Italy)

Restoration and structural reinforcement of the Bell tower of St. Zeno's Church, Verona (Italy)

Restoration and structural reinforcement of the Bell tower of St. Giustina's Church, Padova (Italy)

Restoration and structural reinforcement of the Bell tower of Holy Crown Church, Vicenza (Italy)

Restoration and structural reinforcement of the Bell tower of St. Domenico's Church, Vicenza (Italy)

Restoration and seismic analysis of the oblique Bell tower in Burano Island, Venezia (Italy)

Static restoration and seismic improvement of the San Romedio bell tower at the Basilica of San Vigilio, Trento (Italy)

Restoration and structural reinforcement of the Bell tower of Vangadizza Abbey, Badia Polesine (Rovigo, Italia)

Restoration and structural reinforcement of the Clock Tower, Padova (Italy)

Restoration and structural reinforcement of the Bell Tower of Monza Cathedral, Monza (Italy)

Restoration and seismic improvement of the Bell tower of San Floriano's Parish Church, Verona (Italy)

Restoration and structural reinforcement of Vanga Tower, Trento (Italy)

Restoration and structural reinforcement of the Bell tower of St. Tommaso's Church, Verona (Italy)

Restoration and structural reinforcement of the Bell tower of St. Marco's Church, Pordenone (Italy)

PALACES

PALACES

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- Restoration of Campo di Brenzone medieval village, Verona (Italy)
- Restoration of Loggetta palace in Monselice, Padova (Italy)
- Consolidation and structural reinforcement of the Galliera Veneta imperial villa, Padova (Italy)
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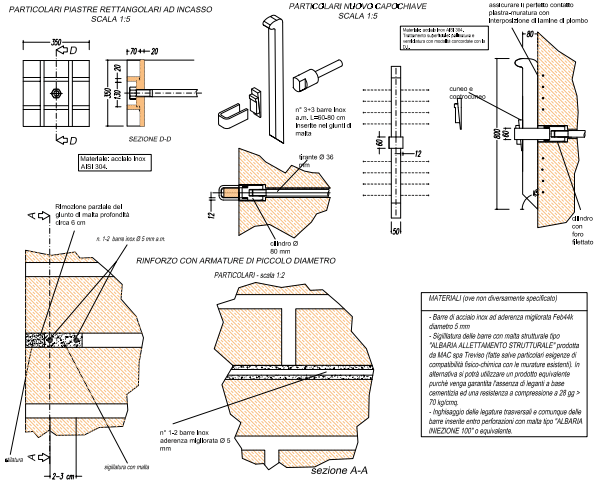
- Structural reinforcement in the Juliet's House in Verona (Italy)
- Restoration of the Civic Library of Verona (Italy)
- Seismic improvement and restoration of Gonzaghesco Palace, seat of the Municipality of Poggio Rusco (Mantua, Italy)
- Restoration of Palazzo Bonazzi, seat of the Municipality of Ostiglia (Mantua, Italy)
- Requalification as a Municipal Library of the former Equipe 5 building in Mezzolombardo (Trento, Italy)

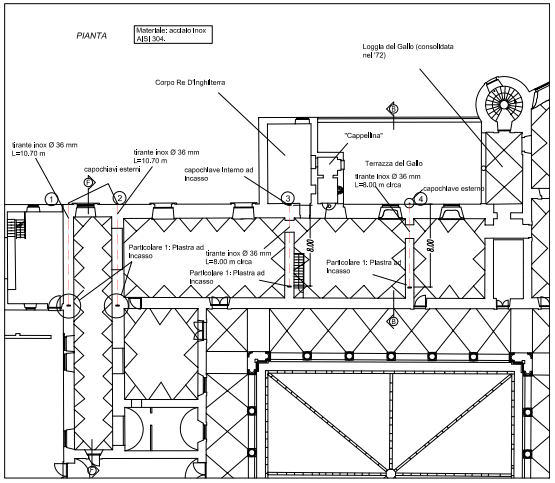
Restoration and seismic improvement of the Ducal Palace, Urbino (Italy), 2001-2006

Detailed structural design for static consolidation and consulting in supervision of works
Total construction cost: € 7,8 millions

Built by order of Duke Federico da Montefeltro during the 15th century, thanks to the work of three architects Maso di Bartolomeo, Luciano Laurana and Francesco di Giorgio Martini the Palace became one of the most important buildings of the Renaissance. In the 16th century, passing the Duchy under the Della Rovere family, the palace was subject to extensions and changes. After annexation of the Duchy by the Holy See, in 1631, the Palace underwent a slow process of dispossession and degradation, which lasted for centuries. In 1912 the Palace was set up within the Marche National Gallery.
The structure is made of brickwork walls; many of the rooms have vaulted ceilings made of masonry or wattle and plaster surfaces over bearing timber ribs; the coverage has a timber structure.
The project involved consolidation considering the actual situation of the structures, which showed signs due to the age and to the succession of several earthquakes, in addition to static problems caused by the horizontal action of vaults or by the soil subsidence under highly loaded foundation areas, given the building's height. To improve the seismic behavior of the Palace, the project introduced bracing systems at the level of the roof structures and integrating the existing system of rods with new stainless steel elements.

PALACES


PARTICOLARI PIASTRE RETTANGOLARI AD INCASSO
SCALA 1:5
SEZIONE D-D
Materiale: acciaio Inox AISI 304.
PARTICOLARI NUOVO CAPOCHIAVE
SCALA 1:5
Materiale: acciaio Inox AISI 304. Trattamento superficiale: sabbiatura e sverniciatura con nocciolo di cocciolato con fibra
n° 3+3 barre Inox aum. L=60-80 cm inserite nei giunti di malta
tirante Ø 36 mm
cilindro Ø 80 mm
cuneo a cappuccino
assicurare il perfetto contatto piastra-muratura con interposizione di lamine di piombo
cilindro con foro filettato
Rimozione parziale del giunto di malta profondità circa 6 cm
n. 1-2 barre Inox Ø 5 mm a cn.
RINFORZO CON ARMATURE DI PICCOLO DIAMETRO
PARTICOLARI - scala 1:2
n° 1-2 barre Inox aderenza migliorata Ø 5 mm
sigillatura con malta
2-3 cm
sezione A-A
MATERIALI (ove non diversamente specificato)
- Barre di acciaio inox ad aderenza migliorata Feb44k diametro 5 mm
- Sigillatura delle barre con malta strutturale tipo "ALBARIA ALLETTAMENTO STRUTTURALE" prodotta da MAC spa Treviso (fatte salve particolari esigenze di compatibilità fisico-chimica con le murature esistenti). In alternativa si potrà utilizzare un prodotto equivalente purchè venga garantita l'assenza di leganti a base cementizia ed una resistenza a compressione a 28 gg > 70 kg/cmq.
- Inghisaggio delle legature traversali e comunque delle barre inserite entro perforazioni con malta tipo "ALBARIA INIEZIONE 100" o equivalente.


PIANTA
Materiale: acciaio Inox AISI 304.
Loggia del Gallo (consolidata nel '72)
Corpo Re D'Inghilterra
"Cappellina"
Terrazza del Gallo
tirante inox Ø 36 mm L=10,70 m
tirante inox Ø 36 mm L=10,70 m
capochiavi esterni
capochiave Interno ad incasso
tirante inox Ø 36 mm L=8,00 m circa
capochiave esterno
Particolare 1: Piastra ad Incasso
tirante inox Ø 36 mm L=8,00 m circa
Particolare 1: Piastra ad Incasso
Particolare 1: Piastra ad Incasso
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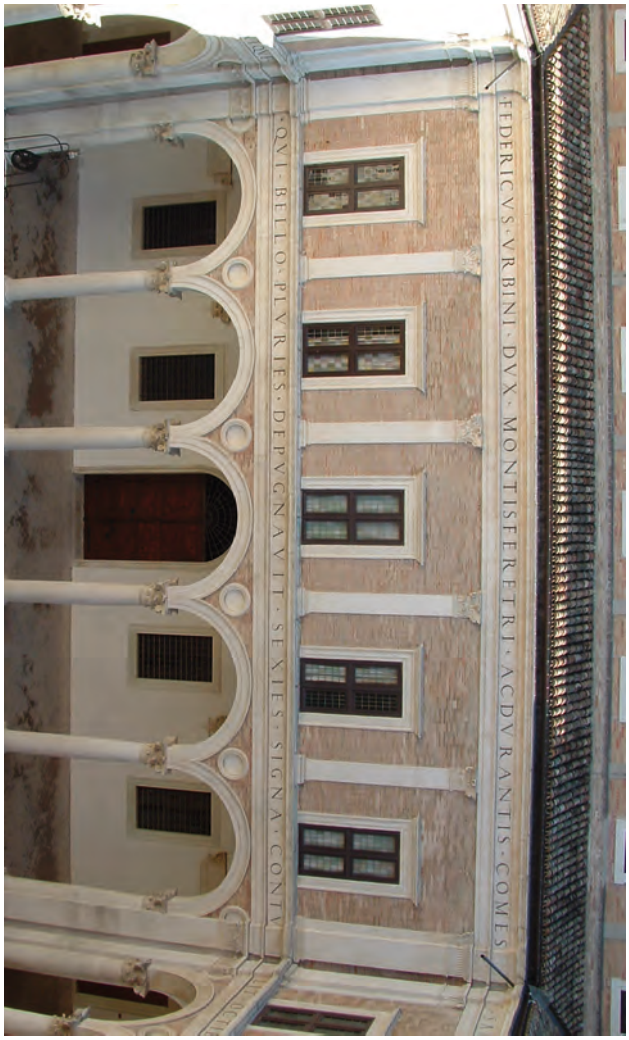
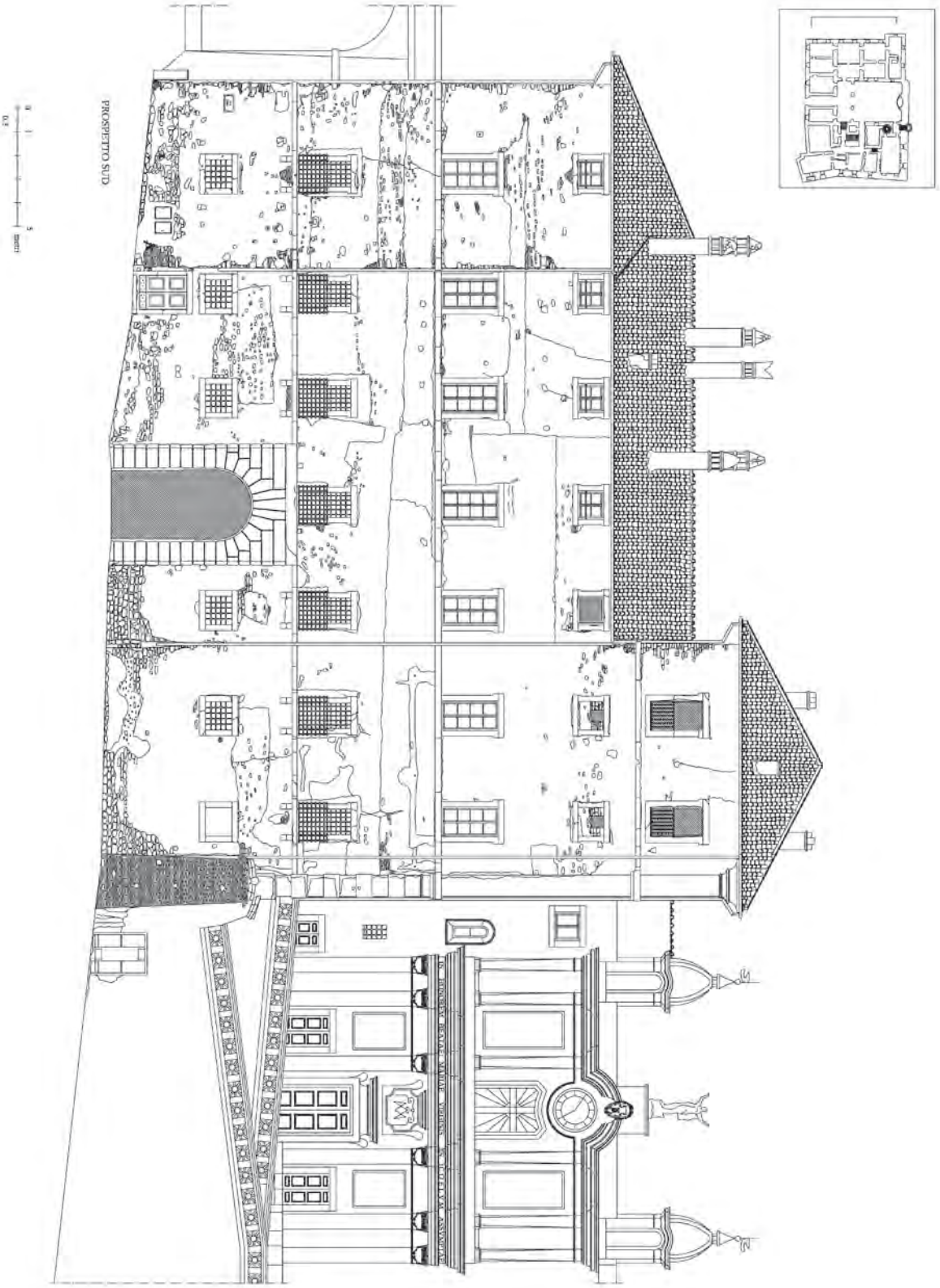
6,00


FEDERICVS·VRBINI·DVX·MONTISFERETRI·ACDVRANTIS·COMES
QVI·BELLO·PLVRIES·DEPVGNAVIT·SEXIES·SIGNA·CONTV

Restoration and seismic improvement of Giustiniani - Odescalchi's Palace, Bassano Romano, Viterbo (Italy), 2012-2013

Expert advice to the supervision of work
Total construction cost: € 600.000

The palace is a medieval castle, that was transformed in the sixteenth century by Giuseppe Giustiniani. He achieved a magnificent house with a great park. A bridge connects the courtyard to the park. On the first floor of the house, the rooms have vaults and walls with important frescoes. In the middle of XXth century the Cultural Heritage Office (Soprintendenza dei Beni Culturali) bought the building in order to restore and reuse it. In the previous period the last owner, the Odescalchi's family, made fall this building in a very bad conditions. The new owner started several operations of consolidation and retrofitting of the building, focusing their efforts on roof restoration.
In one hand, due to its critical conditions of conservation, the timber roof situated in the south corner of this historical construction was completely restored/reconstructed. On the other hand, it has been possible restoring and consolidating the ceiling in the West part of the building, using timber or steel prosthesis.
The seismic behaviour of the main facades has been improved with steel ties.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APRILIS
MAIVS
IVNIVS
IVLIVS
AVGVSTVS
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Restoration, functional upgrading and staging of the museum complex of the Academy Galleries (first and second floor), Venice (Italy)

Conservative restoration and cultural valorization with residential adjustment of the former St. Silvestro Monastery, Verona (Italy)

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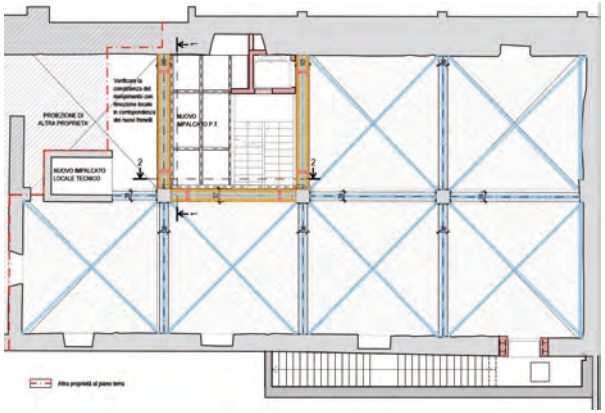


Requalification as a Municipal Library of the former Equipe 5 building in Mezzolombardo (Trento, Italy)

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT

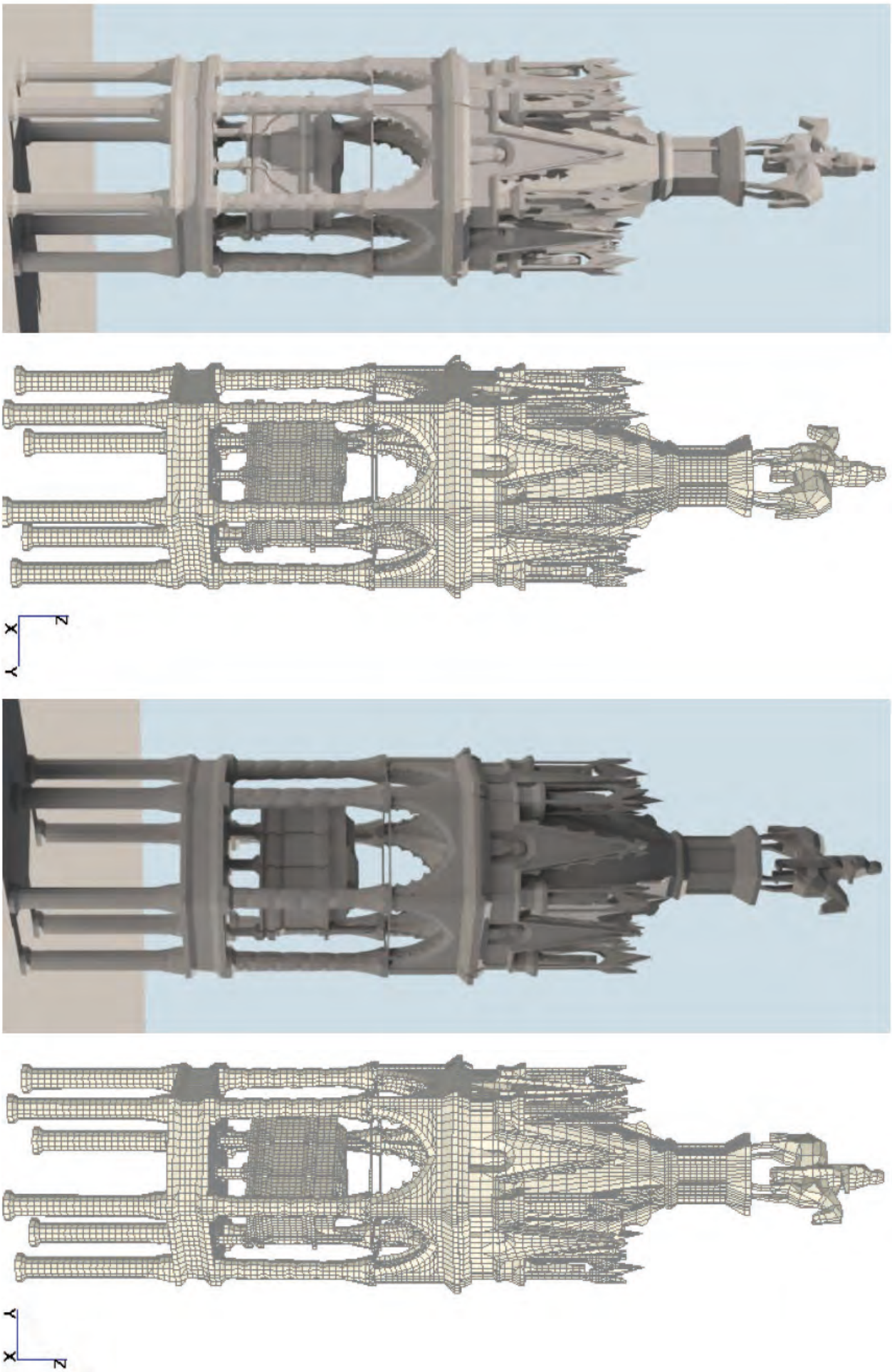
- Restoration of Scaligera arks in Verona (Italy), 2006-2010
- Static and seismic analysis and monitoring of Scrovegni's Chapel, Padova (Italy), 1995-2014
- Structural analysis of Riace Bronzes, Reggio Calabria (Italy)
- Archaeological excavation and restore of the Hypogean masonry tank near S.Peter's Castle, Verona (Italy)
- Restoration of Mariensäule group sculpture, Saltzburg (Austria)
- Restoration of main rose window of St. Zeno's Basilica, Verona (Italy)
- Suspension of Petrarca's Reliquary, Arquà Petrarca (Italy)
- Seismic Isolation of Archaeological Museum Glass Roof, Verona (Italy)
- Glass structure for the roof of the Vicari's Loggia, Arquà Petrarca (Italy)

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT

Restoration of Scaligera arks in Verona (Italy), 2006-2010

Design and supervision of works
Total construction cost: € 860'000

The family which reigned on Verona's city in the medieval age created a groups of Scaligera Arks that are monumental tombs of the regnant. The interventions were on two of them: once on the Cansignorio della Scala ark and the other on the Mastino della Scala one.
The first is the Cansignorio della Scala's ark, it dates back on about 1375 and it was designed by 'Bonino da Campione' and built by craftsman from Campione. It is chronologically the latter and it is a precious demonstration of the extreme gothic style in the Padan area. Form a constructive point of view it shows as a complex sculpture made by Candoglia marble. The structural interventions, carried out from the 2006 to 2010 concerns the improvement of the behaviour and the consolidation of the degradations and damages.
The main concept was the minimum intervention with simple and localized insertion of advanced material with and high durability (stainless steel ties, titanium bushing) with the less number of drillings. Moreover the final intervention is low visible and completely removable.
An important role was played also by the continuous SHM, it is active since the design phase, and still working on site. The role of this technology is manage the safety conditions of the monument with the minimum intervention on heritage, hence preserving as much as possible its significance. The intervention on the other ark regards strengthening of the horse leg by means of FRP.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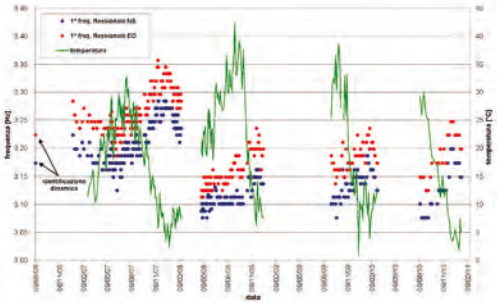
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1° freq. Ressonante EO
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identificazione dinamica
frequenza [Hz]
temperatura [°C]
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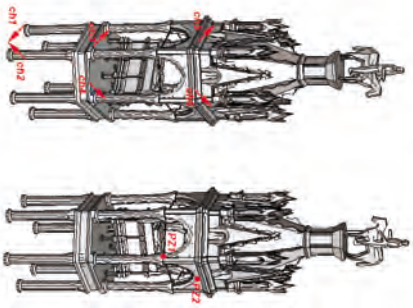
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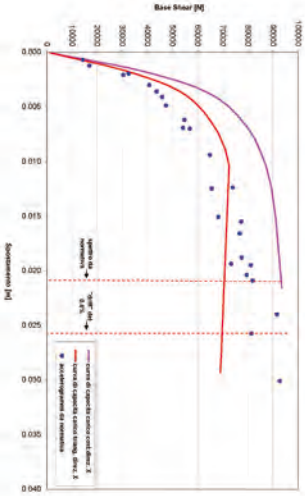
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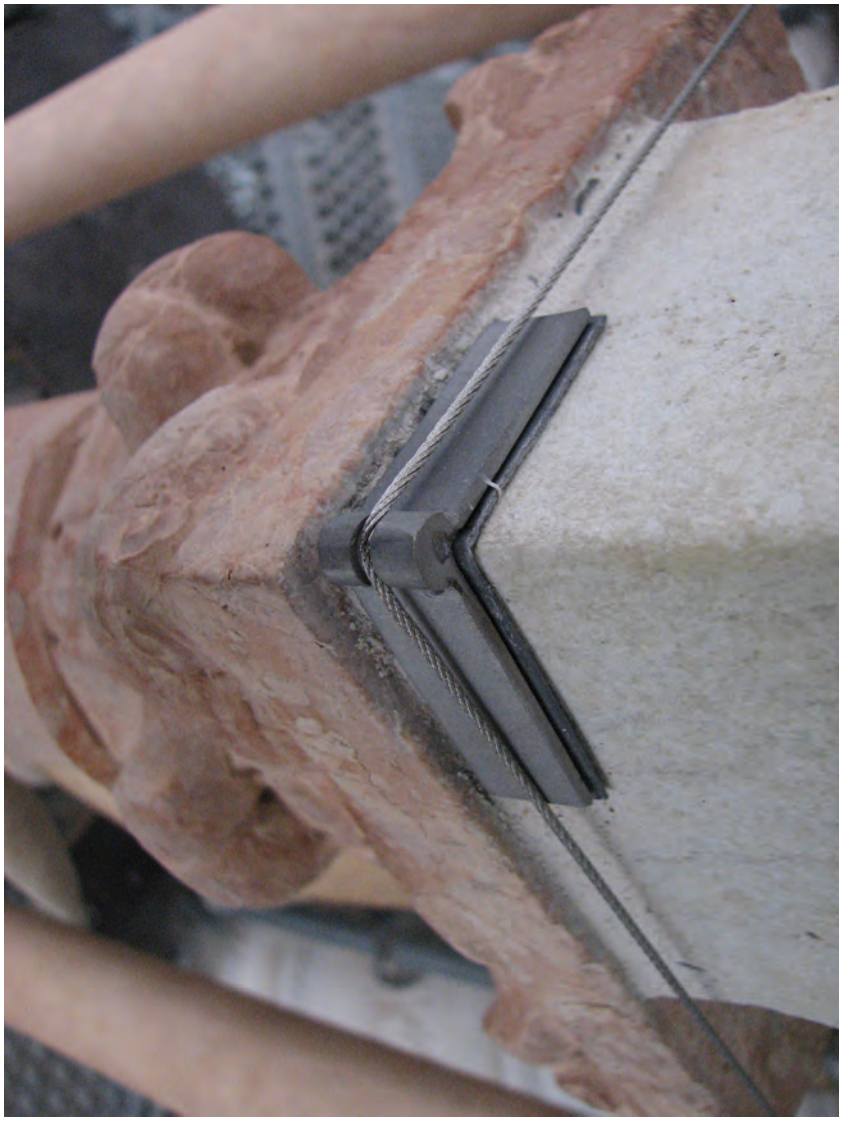
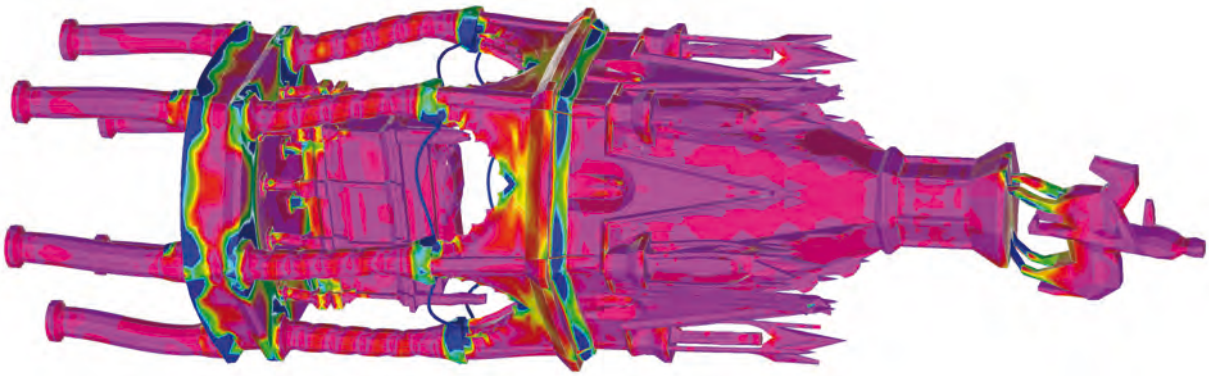


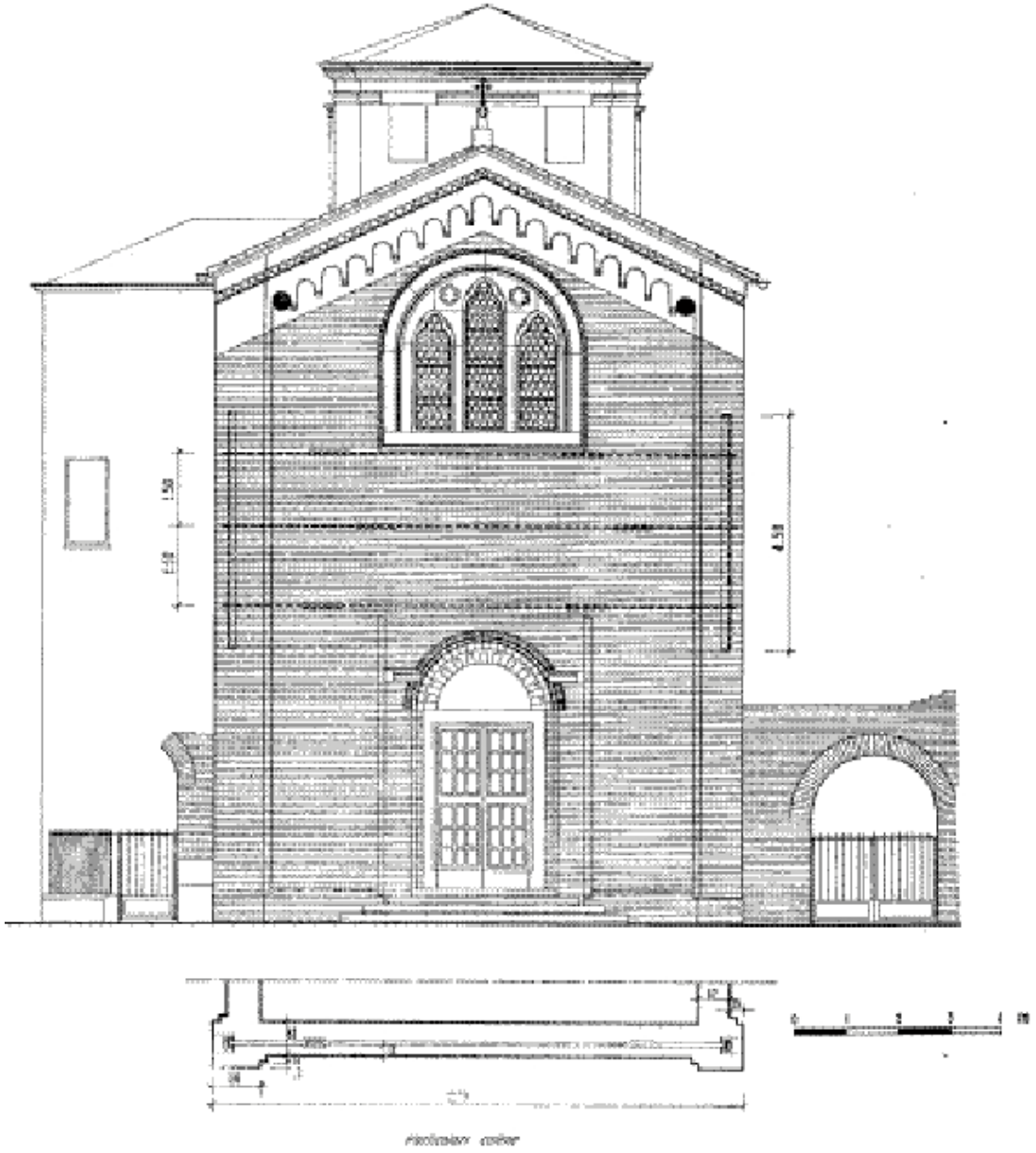


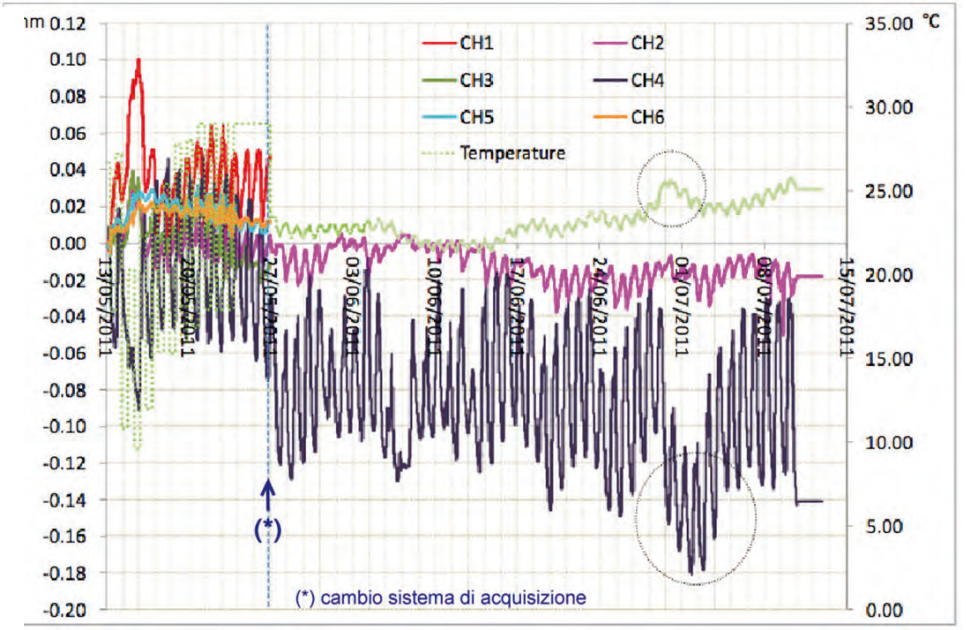
Static and seismic analysis and monitoring of Scrovegni's Chapel, Padova (Italy), 1995-2014

Overall study and survey of behaviour and state condition to preserve the Giotto's frescoes
Total restoration costs: € 750'000

The Scrovegni's Chapel was constructed in 1300, it is a masonry building which host the cycle of Giotto's frescoes. These paintings illustrate stories of the Virgin Mary and Christ. The construction was at the beginning the internal chapel of the great palace of the Scrovegni family. The current state is the result of several transformations where the meaningful are: the porch collapse (1817), the palace demolition ('800) and the restoration interventions carried out until the 1963 when the original ties and the roof were substituted by new ones.
A systematic testing and survey of the plaster consistency and of the structural behaviour started since the 1995 and it is still in progress. It is an activity parts within an overall project of conservation held together by the municipality and the Ministry of Heritage and Cultural Activity (MiBAC) with the aim to guarantee the best conservation state as possible after the restoration of 2002.
The Central restoration institute (now ISCR in Italy) between the 2001 and 2002 performed a restoration of the whole painting cycle.
The tests schedule is based on non destructive tests and it regards the control of the most relevant parameters of local and global structural behaviour. The tests are both periodical and continuous and they check direct , indirect measure and with them also some back analysis.

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT




CH1
CH2
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Temperature
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(*) cambio sistema di acquisizione
13/05/2011
03/06/2011
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17/06/2011
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01/07/2011
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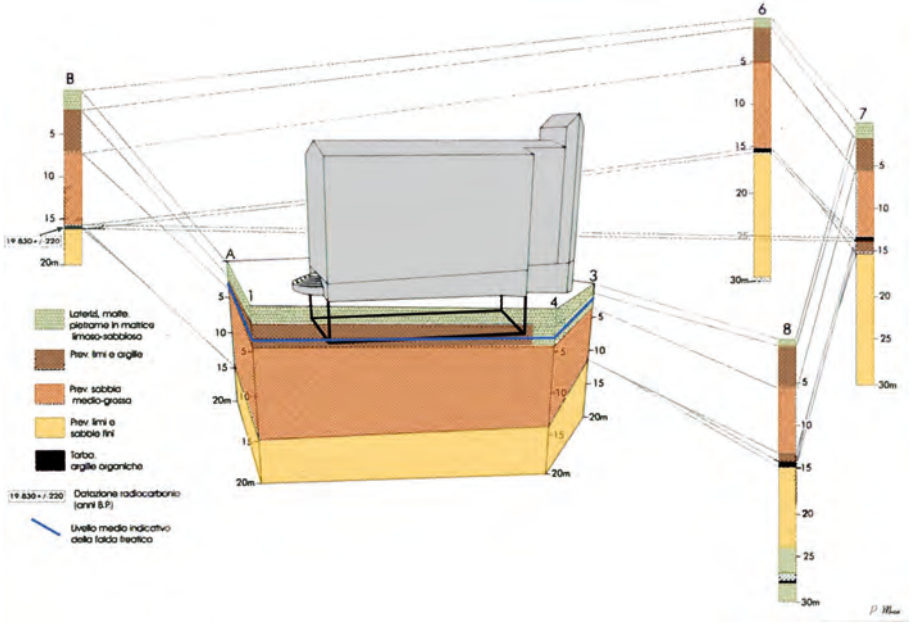
A
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20m
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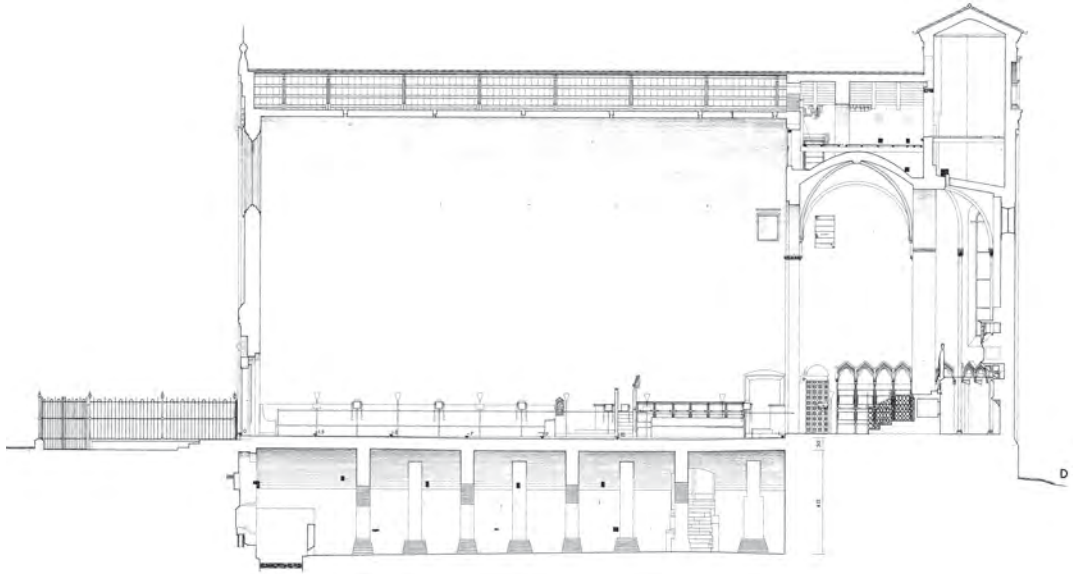
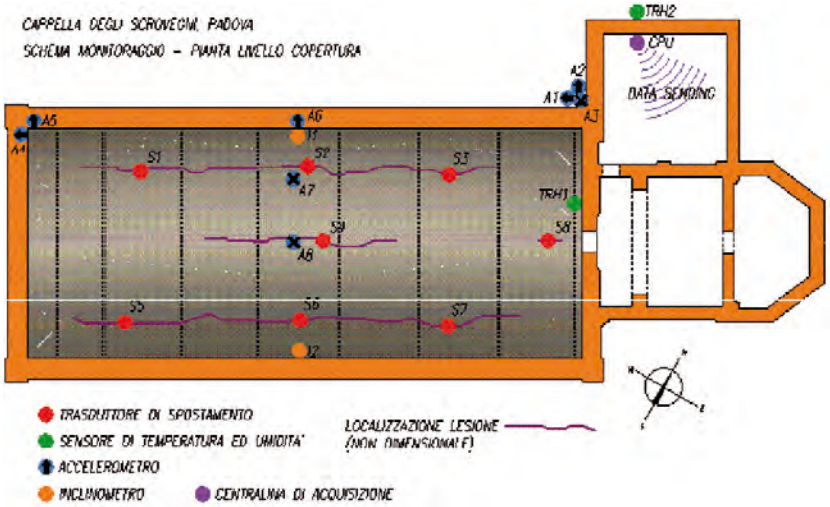
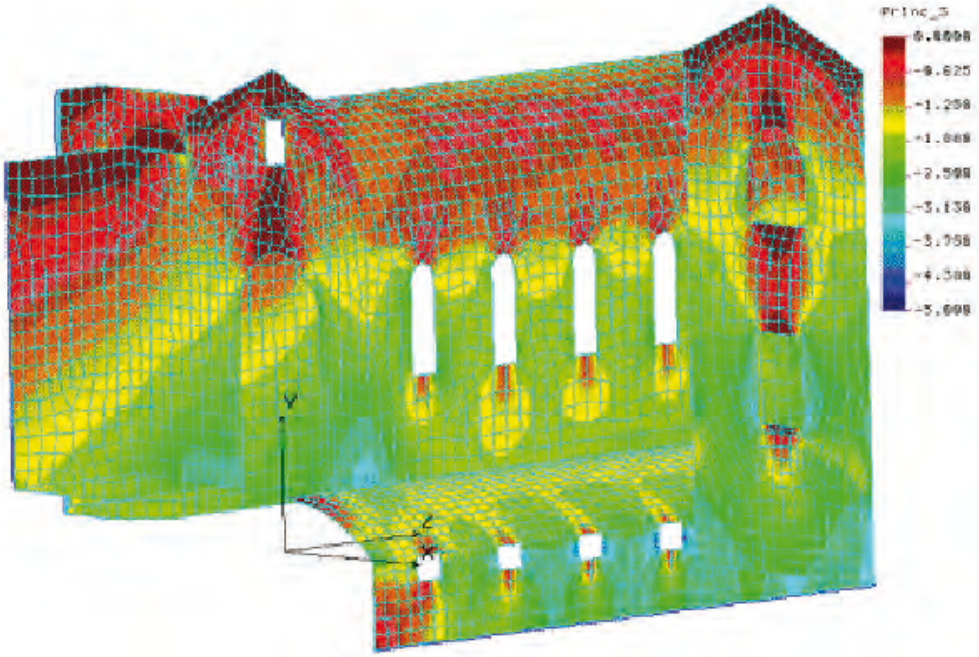
Laterizi, malte, pietrame in matrice limoso-sabbioso
Prev. limi e argille
Prev. sabbia medio-grossa
Prev. limi e sabbie fini
Torba, argille organiche
Datazione radiocarbonio (anni B.P.)
Livello medio indicativo della falda freatica




CAPPELLA DEGLI SCROVEGNI, PADOVA
SCHEMA MONITORAGGIO – PIANTA LIVELLO COPERTURA
TRH2
CPU
DATA SENDING
A1
A2
A3
A4
A5
A6
A7
A8
I1
I2
S1
S2
S3
S4
S5
S6
S7
S8
TRH1
TRASDUTTORE DI SPOSTAMENTO
SENSORE DI TEMPERATURA ED UMIDITA'
ACCELEROMETRO
INCLINOMETRO
CENTRALINA DI ACQUISIZIONE
LOCALIZZAZIONE LESIONE
(NON DIMENSIONALE)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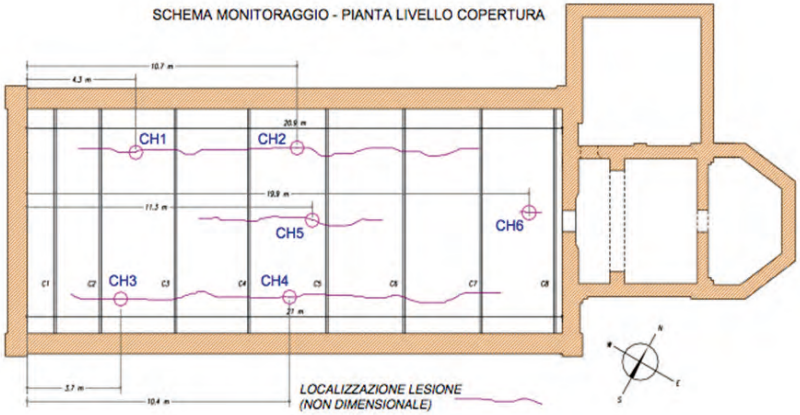
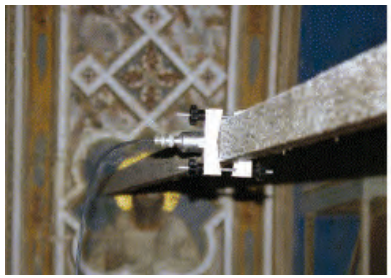
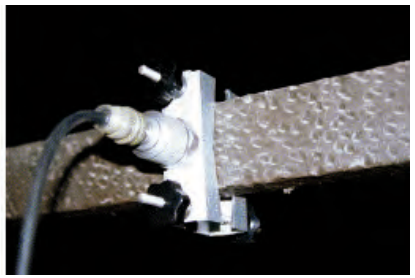
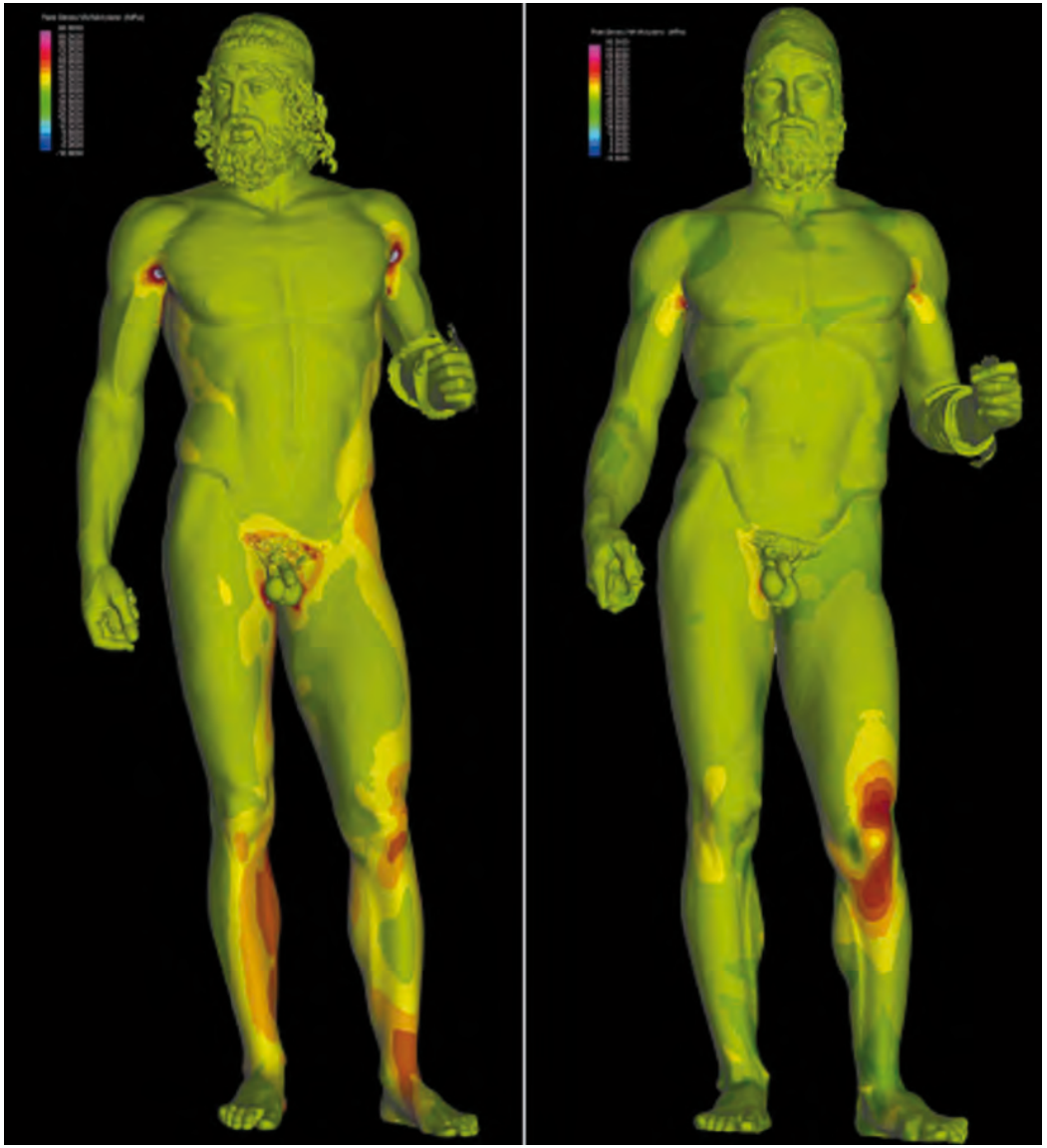

SCHEMA MONITORAGGIO - PIANTA LIVELLO COPERTURA
CH1
CH2
CH3
CH4
CH5
CH6
LOCALIZZAZIONE LESIONE
(NON DIMENSIONALE)






H

STRUCTURAL HEALTH MONITORING AND SAFETY MANAGEMENT



Riace Bronzes, Reggio Calabria (Italy)

Archaeological excavation and restore of the Hypogean masonry tank near S.Peter's Castle, Verona (Italy)

Restoration of Mariensäule group sculpture, Saltzburg (Austria)

Restoration of main rose window of St. Zeno's Basilica, Verona (Italy)

Suspension of Petrarca's Reliquary, Arquà Petrarca (Italy)

Seismic Isolation of Archaeological Museum Glass Roof, Verona (Italy)

Glass structure for the roof of the Vicari's Loggia, Arquà Petrarca (Italy)

TECHNOLOGICAL SOLUTIONS FOR ARTISTIC OBJECTS

TECHNOLOGICAL SOLUTIONS FOR ARTISTIC OBJECTS

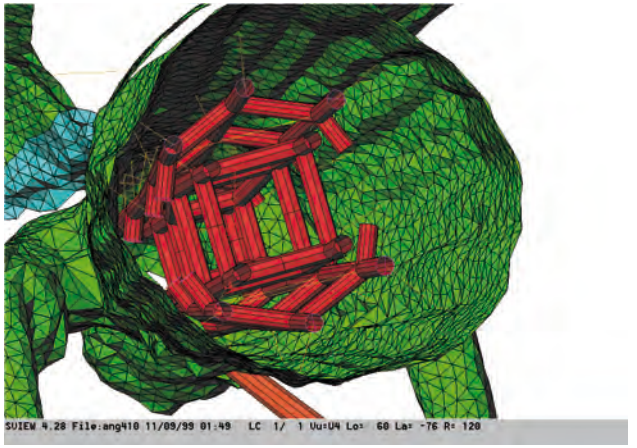
- Support structure inside of the statue of the angel in St. Anthony's Curch, Padova (Italy), 1999
- Reconstruction of the exhibition structure for the Fra' Mauro's world map in the Marciana National Library, Venezia (Italy), 2009-2014
- Structural consolidation as part of the restoration works of the Equestrian Statue of Mastino II, Verona (Italy)
- Static consolidation of statues on facade and pediment of Cathedral Dome, Urbino (Italy)
- Monument in memory of the Second World War deportees, Verona (Italy)
- Structural consolidation as part of the restoration works of the Statues in the area of "Prato Della Valle", Padova (Italy)
- Restoration of the Ariostea column, Ferrara (Italy)

Support structure inside of the statue of the angel in St. Anthony's Curch, Padova (Italy), 1999

Concept and design of internal structure of the statue

The angel statue, placed on the top part of the conic dome, was originally a wind indicator. In occasion of the Jubilee in 2000 the church was restored and during the degradation survey the statue presented severe damage due to corrosion. To restore the angel a too invasive and strong intervention was needed and it was not compatible with its heritage value. With this idea, the original statue has been placed inside the Basilica in a less strict environment, and on the top of the dome a copy has been installed.
The main problems were related to: the environmental exposition in terms of wind and lightning of the element, and the about 80 meters of height in the centre of the Basilica. In these conditions the periodic maintenance it is almost impossible.
The design, developed together with the model calculations, was carried out based on a survey with a 3D laser scan. The copy, made by skilled craftsman on the basis of molds, is composed of a shell with a sandwich structure made of carbon fibre and glass connected to an inner frame made of stainless steel by means of bushings embedded during lamination. Than the statue was covered in gold leaf as detected by some traces of the original decoration . The characteristics of the materials used were verified by laboratory tests. Special attention has been given to the construction stages which were particularly delicate due to the uncomfortable position.

TECHNOLOGICAL SOLUTION FOR ARTISTIC OBJECT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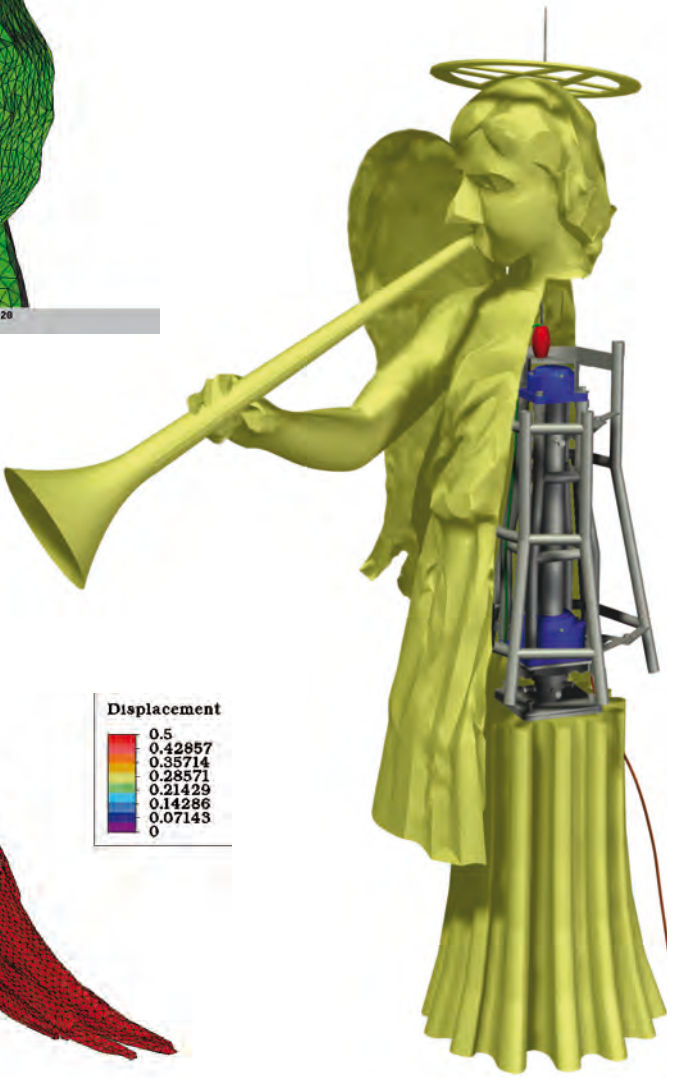


Displacement
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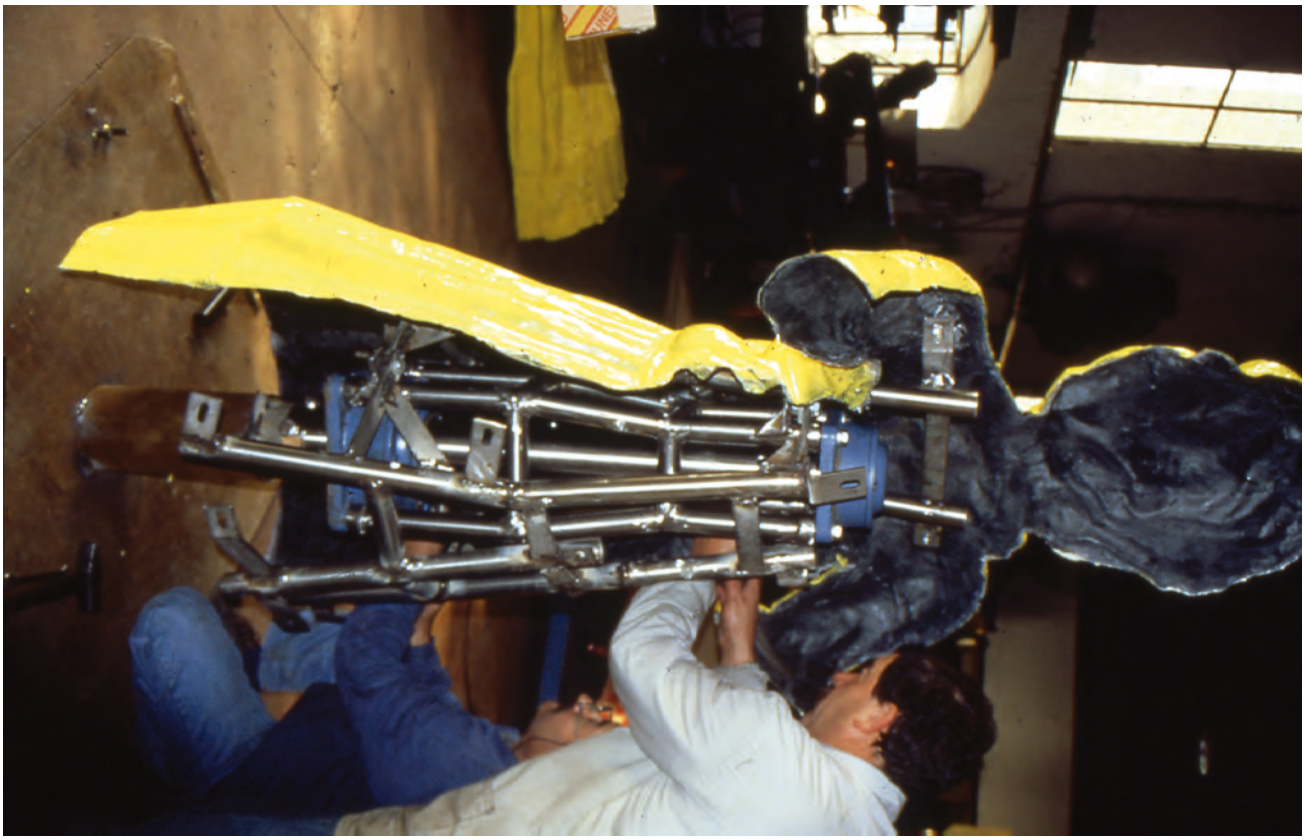
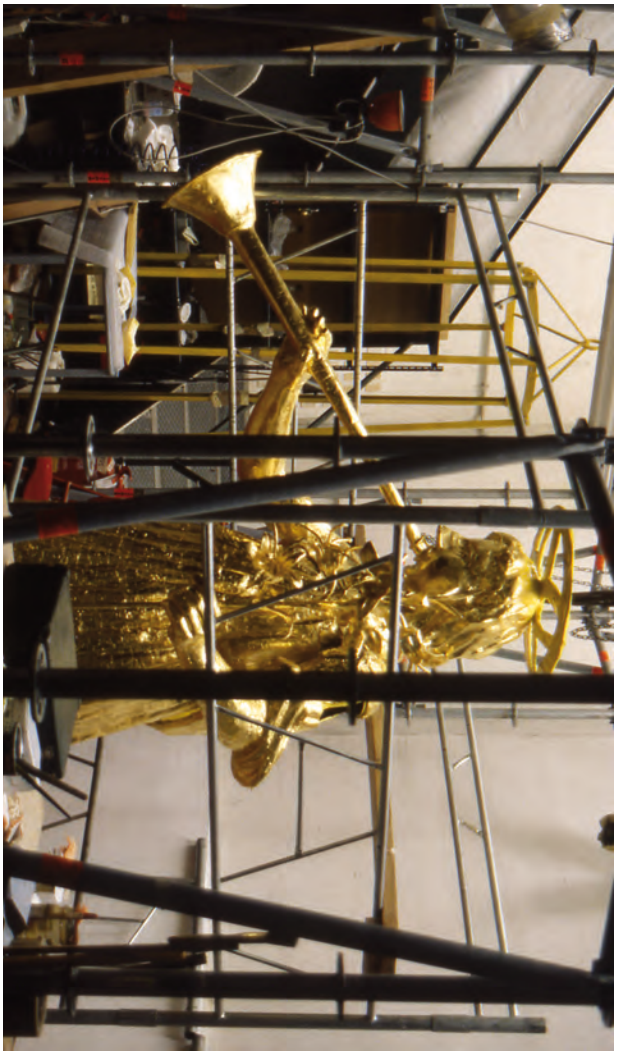
Prof. Ing. M





Reconstruction of the exhibition structure for the Fra' Mauro's world map in the Marciana National Library, Venezia (Italy), 2009-2014

Design of the exhibition frame

The world map of Fra 'Mauro (dates back 1450) is considered one of the greatest late-medieval cartographic artifacts and it is preserved at the Marciana Library in Venice.
The inscriptions were drawn on sheets of parchment glued on a timber support. The circumference of the large circular hemisphere has a diameter of about 2 meters while the overall size of the square frame which hold the world map are approximately 2.3 x 2.3 meters.
The study was focused on the structural aspects related to the construction of the new exhibition structure after the recent restoration work. The steel frame has been designed taking into account the seismic action as well as any accidental actions due to knocks. There was particular attention on the engagement system and its several components to avoid any tampering with the historical elements. A proper study of the mating systems has been done. It would ensure the stability of the various parts of the heritage without hindering movement or expansion typical of the timber structures.
The design has considered the needs caused by the assembly, disassembly and transport since it was expected that the work could be lent to other museums for temporary exhibitions. From November 2013 to March 2014 the globe has been exhibited at the National Library of Australia (Canberra) in the exhibition "Mapping Our World: Terra Incognita to Australia" which was the masterpiece.

TECHNOLOGICAL SOLUTION FOR ARTISTIC OBJECT

TECHNOLOGICAL SOLUTION FOR ARTISTIC OBJECT

Structural consolidation as part of the restoration works of the Equestrian Statue of Mastino II, Verona (Italy)

Static consolidation of statues on facade and pediment of Cathedral Dome, Urbino (Italy)

Monument in memory of the Second World War deporte-es, Verona (Italy)

Structural consolidation as part of the restoration works of the Statues in the area of “Prato Della Valle”, Padova (Italy)

Restoration of the Ariostea column, Ferrara (Italy)

BRIDGES

BRIDGES

- Restoration and strengthening of timber “Alpini” bridge across the Brenta river, Bassano del Grappa (Vicenza, Italy)
- Strengthening and seismic improvement of stone masonry bridge across the Gresal stream, Belluno (Italy)
- Restoration and seismic improvement of the bridge across the Moline stream near S.Lorenzo in Banale (Trento, Italy), 2007-2010
- Structural consolidation of the bridges and banks of Excelsior Grand Hotel access canal, Venice Lido (Italy)
- Consolidation and static adjustment of masonry existing bridges and realization of new pedestrian footbridge across the Tione river, Erbè (Verona, Italy)
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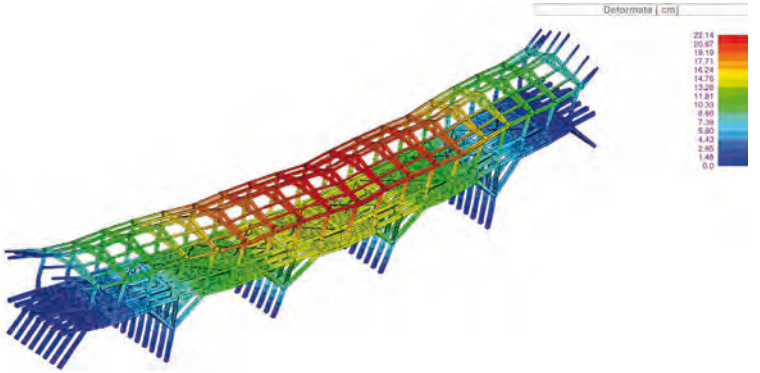
- Structural reinforcement of the damming of the River Adige near Chievo, Verona (Italy)
- Construction design of San Peter footbridge situated in Castello district, Venice (Italy)

Restoration and strengthening of timber “Alpini” bridge across the Brenta river, Bassano del Grappa (Vicenza, Italy)

Detailed strucutural design
Structural works cost: € 3’300’000

The old pedestrian bridge of Bassano, also called “Ponte degli Alpini”, connecting the eastern and western banks of the River Brenta, is a covered timber structure; originated from a design by the architect Andrea Palladio, it has undergone over the centuries many reconstructions and restoration works, due both to damages from the river floods and wars, and to the natural action of deterioration.
The structure, 66 meters long and about 8 meters wide, is divided into five spans (13,20 m long each), supported by four drawn founded in the river through a threshold beam on poles and masonry supports at both eatern and western ends.
The design restoration and strengthening works were studied to achieve the general consolidation of the structural elements of the bridge that, mainly due to the effects of degradation, are no longer able to properly carry out their bearing function, and to resolve, or at least to improve, the global behavior of the structure towards the live loads, in particular the hydraulic thrust and the seismic action. There is also the need, extremely urgent considering the extent of vertical settlements and the results of the recent underwater inspections, to work on the foundation structures, in order to restore their full load-bearing capacity, while improving as much as possible, the conditions of durability along time and maintainability.
Always respecting the criteria of “minimal intervention” and “reversibility”, milestones of the design approach, the design had to evaluate issues calling for the introduction of some reasonable and targeted additional and innovative elements, in order to reach a balanced compromise to optimize the behavior of the old structure, overcoming, if possible and for a reasonable period of time, the serious weaknesses that are currently affecting the stability and already requested, in the recent past, frequent and expensive consolidation works.
In addition to the general restoration of existing timber structures by replacement of the hopelessly degraded ones, the project provides for the introduction of new stainless steel structures at the foundation level and a new bracing element at the level of the pedestrian deck.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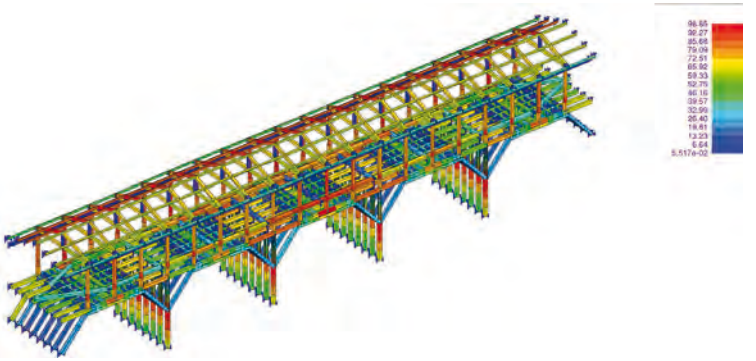
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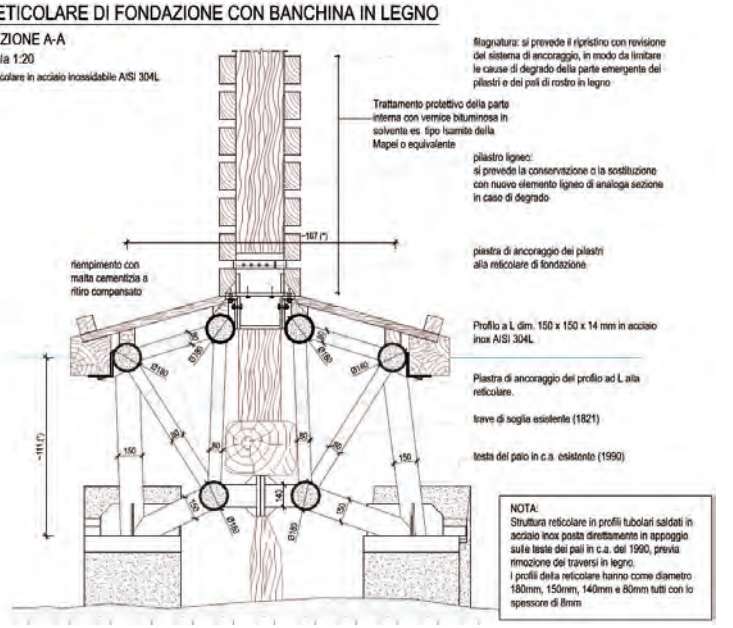
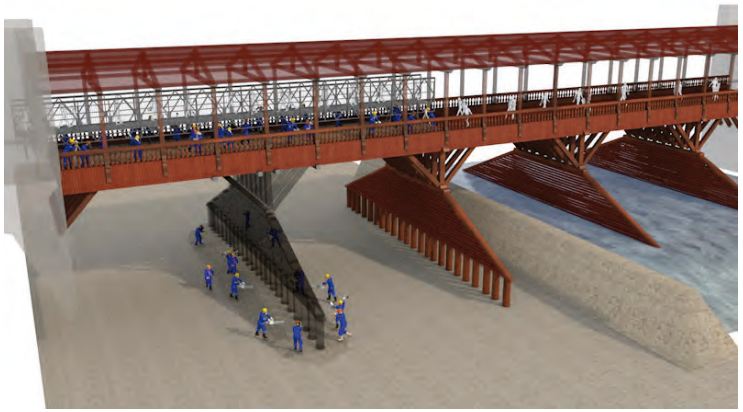
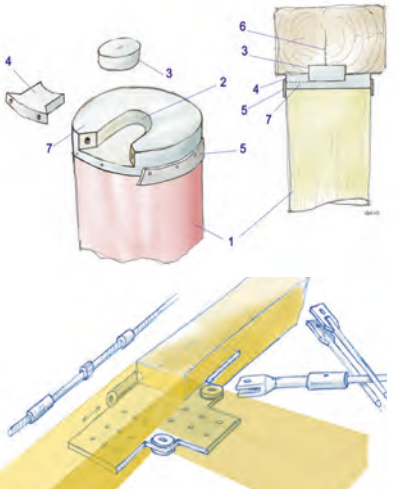

RETICOLARE DI FONDAZIONE CON BANCHINA IN LEGNO
SEZIONE A-A
scala 1:20
Reticolare in acciaio inossidabile AISI 304L
filagnatura: si prevede il ripristino con revisione del sistema di ancoraggio, in modo da limitare le cause di degrado della parte emergente dei pilastri e dei pali di rostro in legno
Trattamento protettivo della parte interna con vernice bituminosa in solvente es. tipo Isamite della Mapei o equivalente
pilastro ligneo: si prevede la conservazione o la sostituzione con nuovo elemento ligneo di analoga sezione in caso di degrado
riempimento con malta cementizia a ritiro compensato
piastra di ancoraggio dei pilastri alla reticolare di fondazione
Profilo a L dim. 150 x 150 x 14 mm in acciaio inox AISI 304L
Piastra di ancoraggio del profilo ad L alla reticolare.
trave di soglia esistente (1821)
testa del palo in c.a. esistente (1990)
NOTA:
Struttura reticolare in profili tubolari saldati in acciaio inox posta direttamente in appoggio sulle teste dei pali in c.a. del 1990, previa rimozione dei traversi in legno.
I profili della reticolare hanno come diametro 180mm, 150mm, 140mm e 80mm tutti con lo spessore di 8mm

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VISTA LATERALE - RETICOLARE DI FONDAZIONE

scala 1:20

Reticolare in acciaio inossidabile AISI 304L

Tiranti di post-tensione con fini Ø22 mm INOX AISI 316 1x19 fili capocorda a pressare filettato (carico rott. 360kN) idoneo a uso strutturale

NOTA:
(*) Tutte le misure e le quote dovranno essere verificate in sito dall'impresa durante i lavori ed adattate in base ai risultati dei tracciamenti (previa approvazione della DL)

NOTA:
Struttura reticolare in profili tubolari saldati in acciaio inox posta direttamente in appoggio sulle teste dei pali in c.a. del 1990, previa rimozione dei traversi in legno.
I profili della reticolare hanno come diametro 180mm, 150mm, 140mm e 80mm tutti con lo spessore di 8mm.

nodo di collegamento tra pilastri in legno e la reticolare di fondazione, vedi dettaglio tavola DE.T.STR.06

PIASTRA TIPO A | PIASTRA TIPO B | PIASTRA TIPO A | PIASTRA TIPO C | PIASTRA TIPO D | PIASTRA TIPO C | PIASTRA TIPO D | PIASTRA TIPO C

NODO A | NODO D | NODO C | NODO E | NODO B

~142 (*) | ~122 (*) | 150 | 150 | 150 | 80 | 80 | 80 | 80 | 80

Variabile (*) | Variabile (*) | Variabile (*) | Variabile (*)

Variabile (*)
nodo di collegamento della reticolare di fondazione ai pali esistenti di fondazione, vedi dettaglio tavola DE.T.STR.06

Direzione della corrente del Brenta

~1016 (*)

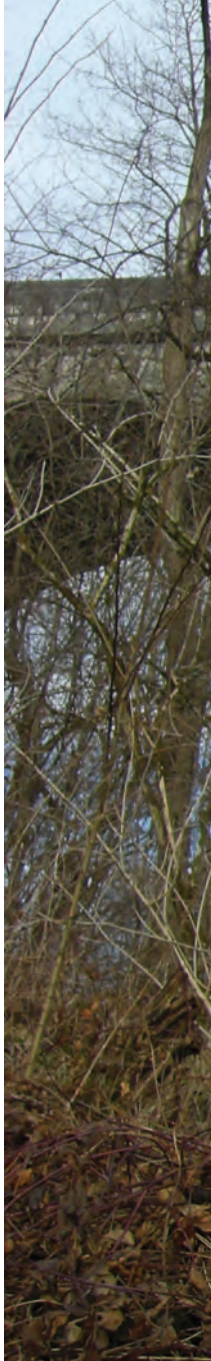
~187 (*) | 180 | 80 | 180 | 140 | 180 | 180

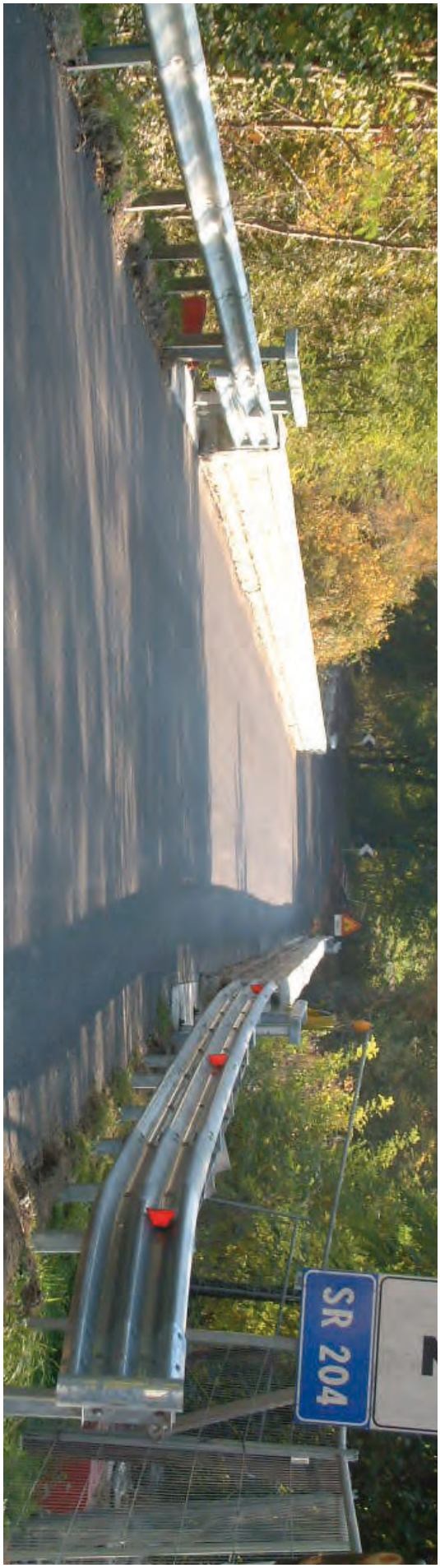
Direzione della corrente del Brenta

Strengthening and seismic improvement of stone masonry bridge across the Gresal stream, Belluno (Italy)

Design and supervision of works
Total construction cost: € 220'000

It is a three-spans stone masonry arch bridge, built in the XIX century. The structure, currently used as a vehicular bridge, has a total length of 67.40 m. The three spans are almost equal, the single arch clear leng¬th being about 15m; their shape is almost semicircular with a radius of 7.39m, slightly increasing at the springing. The average thickness of the arch at the crown is 0.60 m. The maximum height of the two piers, which are tapered between the bottom and the top, is 12.75m. The piers have rectangular section; with dimensions 3.50x6.99m at the base (the bigger dimension orthogonal to the bridge axis). Visual inspection and structural investigations did not show evident structural damages, except for the presence of humidity in the masonry, probably due to insufficient waterproofing.
The seismic analysis evidenced a highly vulnerability to seismic action, mostly due to the slenderness of the high piers. The intervention primarily aimed to improve the seismic resistance of the bridge, fully relying on the intrinsic load-bearing capacity and design characteristics of the existing structure, which was preserved, and even enhanced, in its original configuration.
The capacity of the bridge was increased by the retrofit both in the longitudinal and transverse direction. In the transverse action the new system given by inclined micropiles and r.c. transverse slab act as a portal at the abutment, while at the pier the vertical high strength bars increment the transverse flexural capacity of piers. In the longitudinal direction, the upper r.c. slab is maintained anchored downward by vertical high strength steel bar, thus an effect of confinement is obtained in the infill. At the ultimate limit state, the non-symmetric kinematic mechanism of the arches tends to be activated by horizontal forces. At that point the uplift displacement is contrasted by the confined infill (as an ideal inclined strut), thus incrementing the capacity of the global resistant longitudinal mechanism.



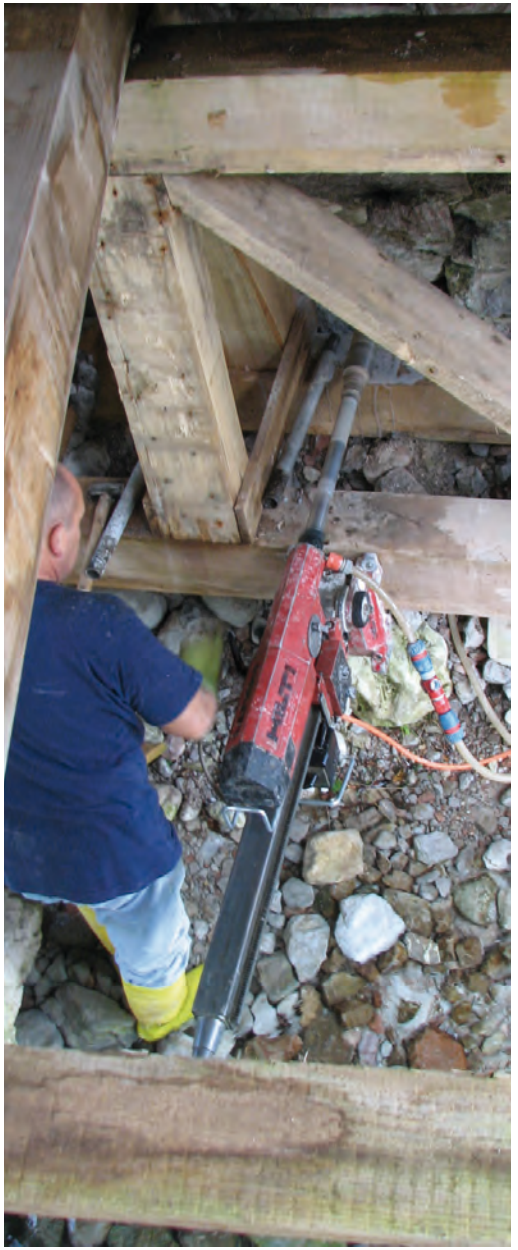

SR 204

Bridge across the Moline stream near S.Lorenzo in Banale (TN, Italy), 2007-2010

Design and supervision of works
Total construction cost: € 250'000

The small stone bridge, probably dating back around the 18th century, is composed of two arches with a central pier set in the middle of the Moline stream bed. The vaults are made of stone blocks (40-45 cm thick), with a filling of loose material. Before intervention, the bridge was severely damaged and had been provisionally secured with a system of temporary shoring made of wood and steel. The original cohesion of masonry was shattered by the deep erosion of mortar joints, due to the gradual run-off. In addition to repairing the damages caused by the erosion and the transit of heavy vehicles, the project provided specific interventions of seismic retrofitting. In particular was performed the installation of transversal ties to bear the internal horizontal actions of the arch and the filling. Moreover was realized a series of masonry buttresses also reinforced with of carbon fibre in order to stabilize the vaults from concentrated loads and any bear horizontal forces due to the seismic action. The portion of the roadway was lowered to its original level , restoring the existing pavement . The interventions were diffuses 'scuci-cuci' and masonry consolidations, injections of grout and joints repointing. All these were conducted with traditional materials compatible with the existing ones.


PONTEGGIO
ALLESTIMENTO
EURO EDILE



Structural consolidation of the bridges and banks of Excelsior Grand Hotel access canal, Venice Lido (Italy)

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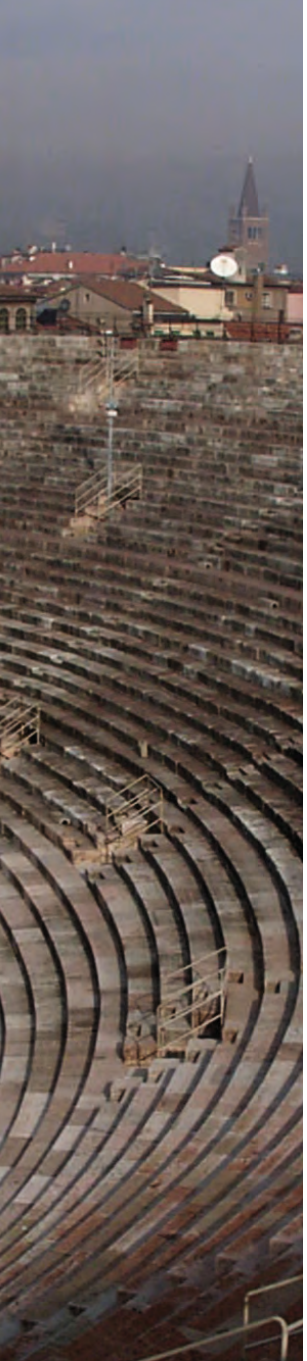
Construction design of San Peter footbridge situated in Castello district, Venice (Italy)



ARCHAEOLOGICAL SITES

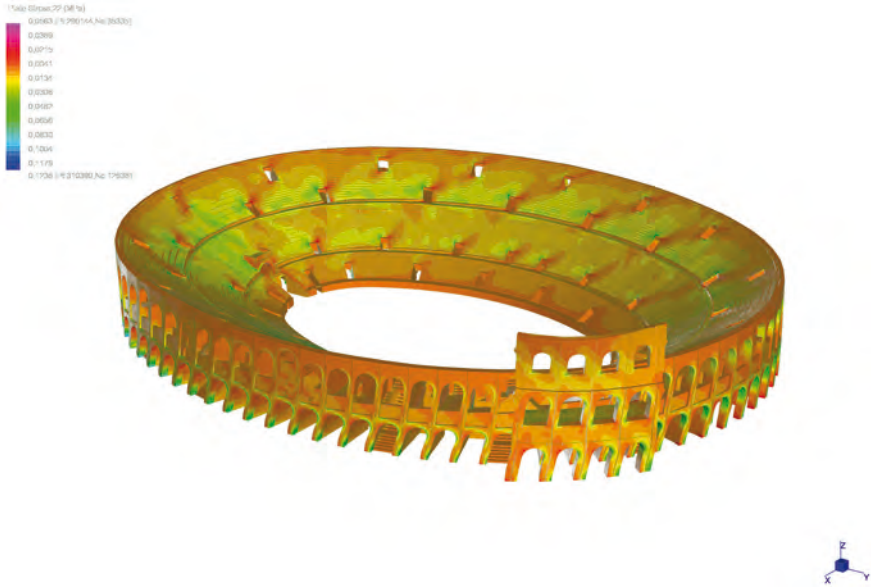
ARCHAEOLOGICAL SITES

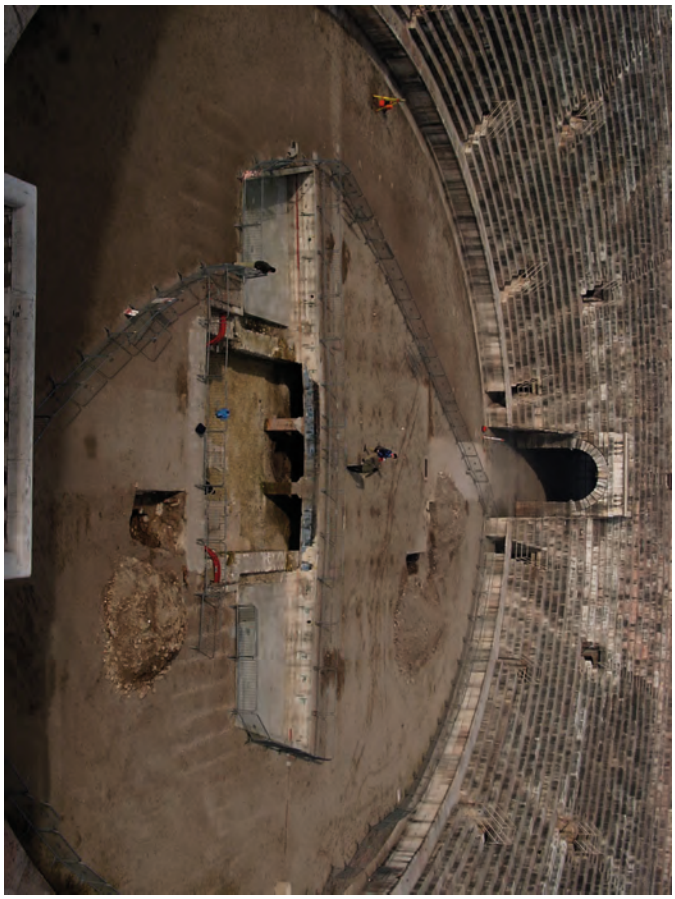
- Restoration, structural reinforcement and monitoring of the Roman amphitheater “Arena”, Verona (Italy)
- Diagnostic, structural analysis and seismic improvement project as part of the restoration works of the Roman aqueduct bridge “Pont d’Ael”, Aymavilles , Aosta (Italy), 2013
- Diagnostic, structural analysis and monitoring of the St. Lorenzo’s Roman bridge, Padova (Italy)
- Structural reinforcement and monitoring of the Archaelogical area around Roman Theatre, Verona (Italy)
- Reconstruction of Bam Citadel (Iran)
- Consolidation and seismic improvement of the Triumphal Gate of the Roman amphitheater, Padova (Italy)
- International Competition for Via dei Fori Imperiali with David Chipperfield Architetcts

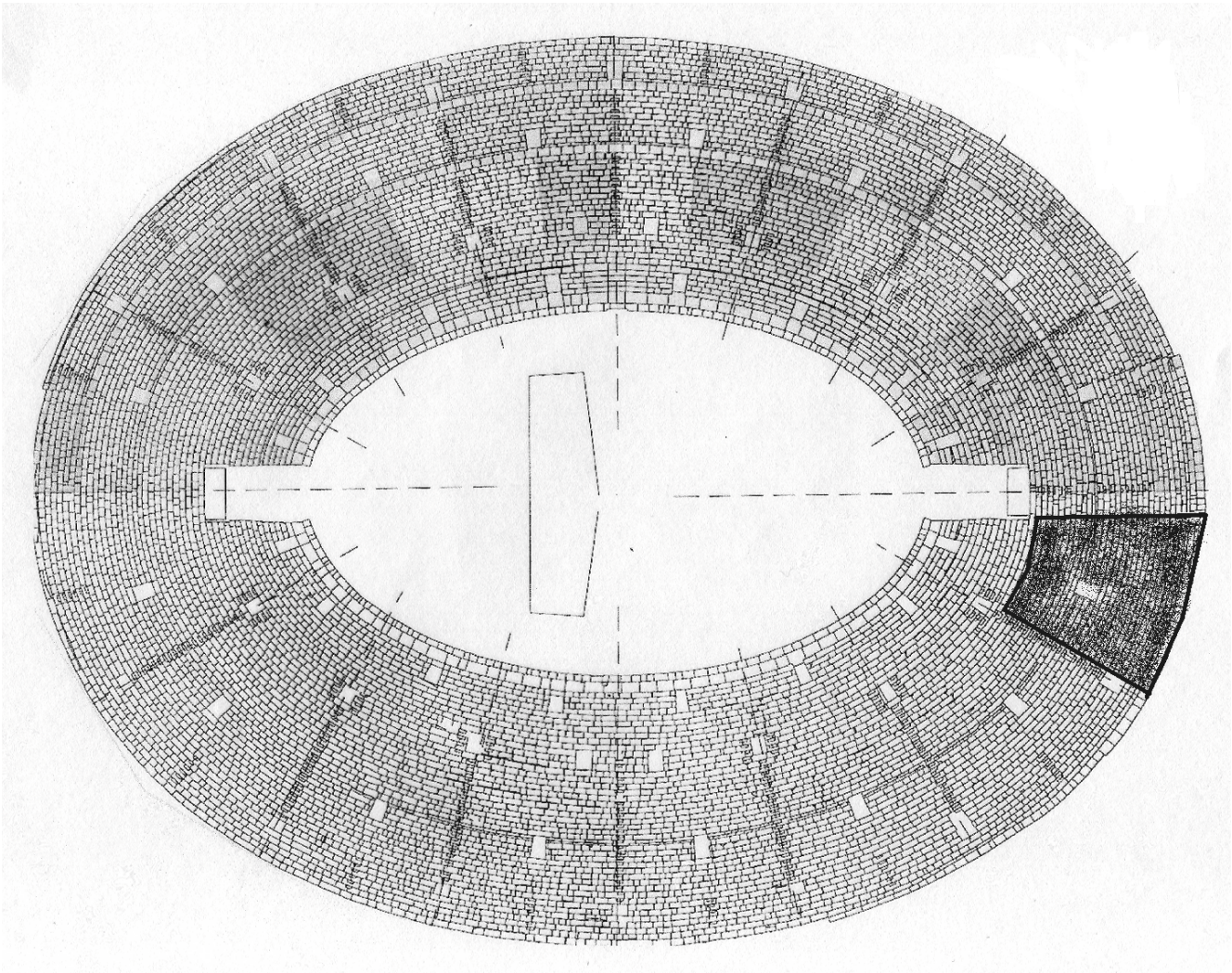
Restoration, structural reinforcement and monitoring of the Roman amphitheater “Arena”, Verona (Italy)

General restoration design, detailed structural design of the pit coverage, security coordination
Total construction cost: about € 25 millions
Pit coverage cost: € 1,15 millions

The Roman amphitheatre of Verona, internationally famous for the lar¬ge-scale opera performances given there, is one of the best preserved ancient structures of its kind. It was built in A.D. 30 on a site which was then beyond the city walls and could host more than 30,000 spectators in ancient times. The round façade of the building was originally composed of white and pink limestone, but after a major earthquake in 1117, which almost completely destroyed the structure’s outer ring, except for the so-called “ala”, the stone was quarried for re-use in other buildings.
The general restoration project was inserted in a comprehensive program of improvement of safety and functionality of the amphitheater, focused in particular on the roof structures of the central pit and underground pas¬sage disposed along the major axis of the amphitheater, consisting since the early sixties, in reinforced concrete slabs supported by the perimeter walls, forming part of the original Roman structure. The coverage of the pit, which also serves as the floor of the pit, with a structure of laminated wood has been completed. The timber structure has been designed so as not to touch the existing masonry structures, as fully supported by new reinforced concrete structures and to allow access to the room below, even if restricted to the purposes specified above, and complete inspection of the walls.



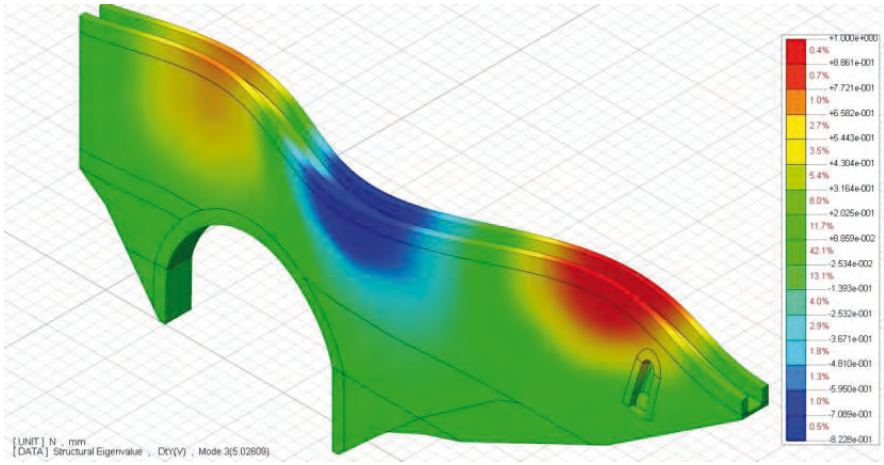




Diagnostic, structural analysis and seismic improvement project as part of the restoration works of the Roman aqueduct bridge “Pont d’Ael”, Aymavilles , Aosta (Italy), 2013

Structural consulting
Total construction cost: € 930’000

As part of the restoration and enhancement of the Pont d’Ael was carried out a structural consulting and seismic design of interventions to improve the structure.
It is an important bridge-aqueduct dating back to 3 B.C., located in the hamlet of Pondel (Aosta), in the gorge of the Grand Eyvia river. The building is made of stone masonry bonded with mortar made of lime and it is long 60 m and width 2.30 m. The structure is divided into two levels: the upper level, which is currently allocated to the walkway, is the ancient path of the water flow from the aqueduct, built by stone slabs of considerable thickness; the lower level is the interior walkway, which was originally not open to the public, used for the control of the estate and the maintenance of the upper plate. The measurements showed the presence of significant lesions placed in correspondence of the dividing walls of connection between the two longitudinal walls.
For the structural analysis of the bridge and for the design of reinforced and seismic improvement has been developed a global model of the bridge with which is been investigated the behavior of the structure subjected to the action of wind and earthquake.
The improvement intervention was aimed at countering the movement of the longitudinal walls out of plane, highlighted by analyzing as the theme of greater vulnerability. The retaining effect, originally assigned to the transverse diaphragm (now cracked), is obtained by the insertion of stainless steel tie rods that connect the two longitudinal walls.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-1.393e-001
4.0%
-2.532e-001
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-3.671e-001
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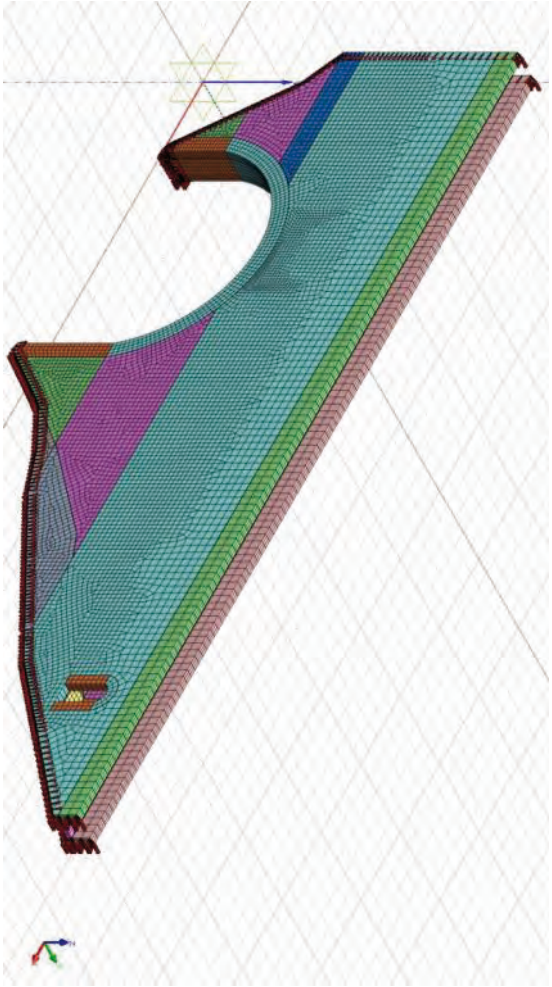

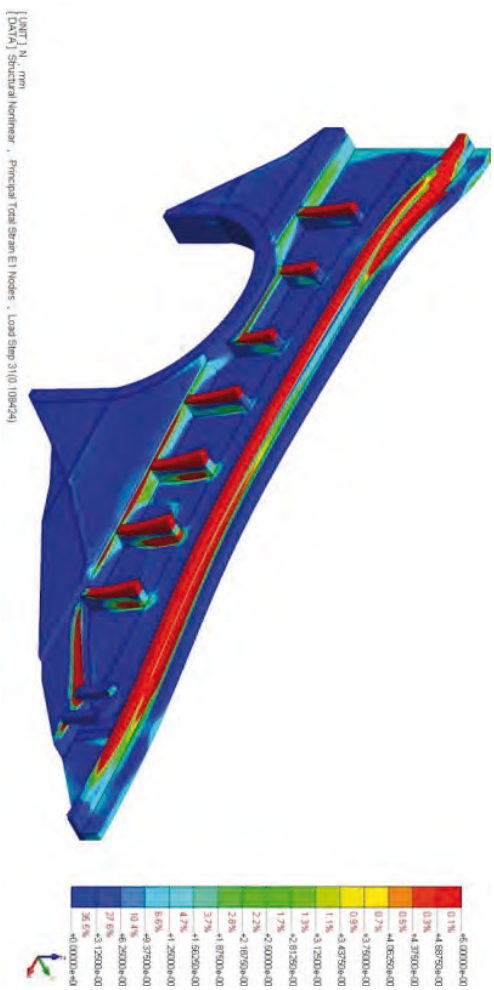
[UNIT] N , mm
[DATA] Structural Nonlinear , Principal Total Strain E1 Nodes , Load Step 31(0.108424)
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0.1%
+4.68750e+00
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+4.37500e+00
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+2.18750e+00
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+1.87500e+00
3.7%
+1.56250e+00
4.7%
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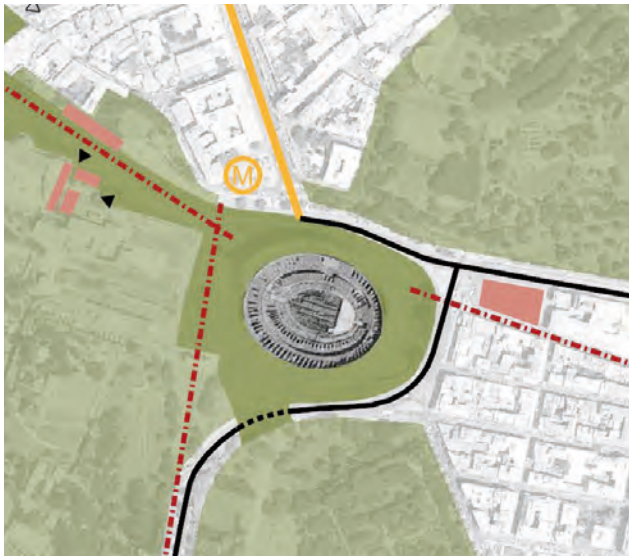
6.6%
+0.93750e+00
10.4%
+0.62500e+00
27.6%
+0.31250e+00
36.5%
+0.00000e+00

Diagnostic, structural analysis and monitoring of the St. Lorenzo's Roman bridge, Padova (Italy)

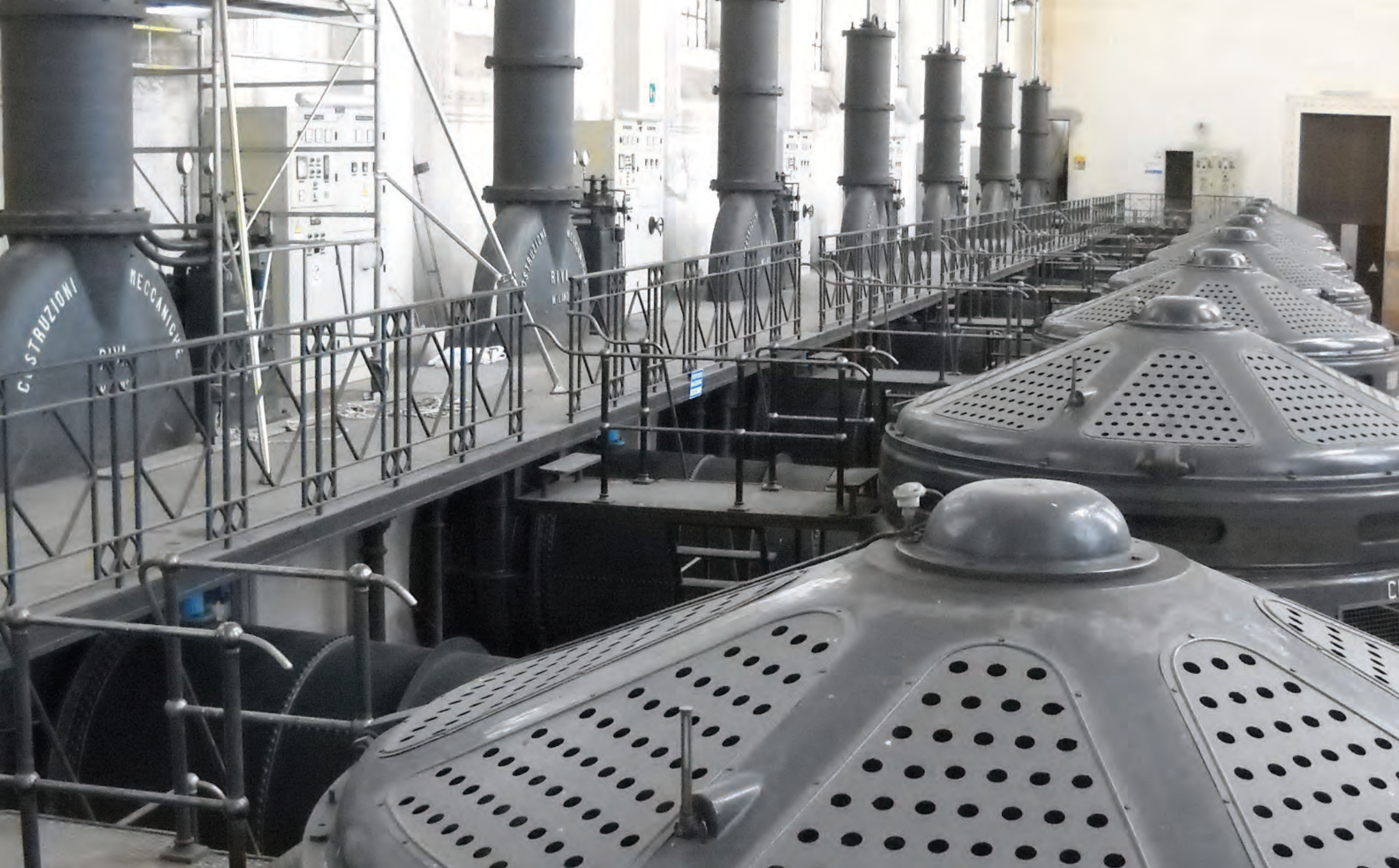
Structural reinforcement and monitoring of the Archaelogical area around Roman Theatre, Verona (Italy)

Reconstruction of Bam Citadel (Iran)

Consolidation and seismic improvement of the Triumphal Gate of the Roman amphitheater, Padova (Italy)



International Competition for Via dei Fori Imperiali with David Chipperfield Architetcts


STRUZIONI
MECCANICHE

POST SEISMIC REPAIR AND STRENGTHENING INTERVENTIONS

POST SEISMIC REPAIR AND STRENGTHENING INTERVENTIONS SITES

- Consolidation and seismic improvement of S. Siro pumping station, St. Benedetto Po, Mantova (Italy)
- Restoration and seismic improvement of St. Silvestro's Church in L'Aquila (Italy), 2013
- Damages restoration and seismic improvement of the Cathedral of St. Peter the Apostle after the earthquake of May 2012, Guastalla (Reggio Emilia, Italy)
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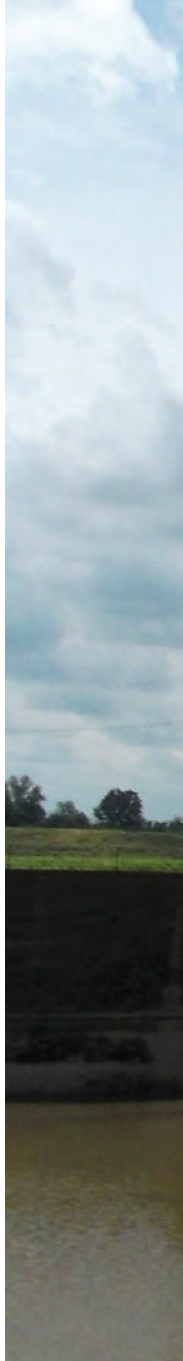
- Restoration and seismic improvement of the St. Domenico's Church, L'Aquila (Italy)
- Damages restoration and seismic improvement of the St. Stefano di Sessanio's ancient village after the earthquake of April 2009, L'Aquila (Italy)

Consolidation and seismic improvement of S. Siro pumping station, St. Benedetto Po, Mantova (Italy), 2012-2014

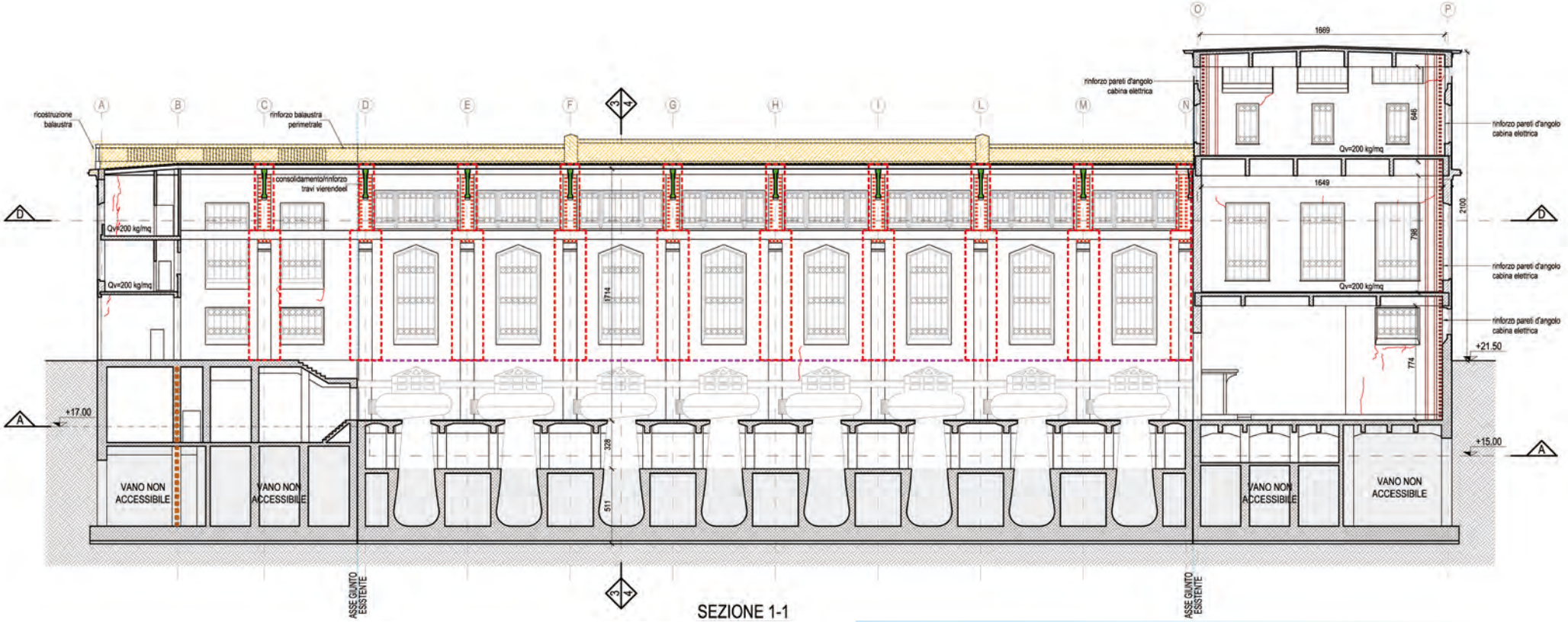
Detailed design and supervision of work
Total construction cost: € 1,5 millions

The plant, which dates to the early Thirties , hosts a battery of 8 lifting pumps for lifting water and stands as a strategic the defense of the territory against the floods of the River Secchia and the flooding of the upstream basin. The building shows a rectangular plant (92.4 x 15 m) and has a flat roof on two levels.
Two medium intensity earthquakes in May 2012 revealed damages related to construction details and building vulnerability (transverse joints causing separate structures with different stiffness against horizontal actions, insufficient connection and reinforcement of r.c. beams supporting the roof).
In order not to alter the characteristics of the cultural heritage building with too invasive interventions, the design aims to achieve an overall improving of the seismic behaviour, not the adjustment, planning to relocate the strategic function of the plant; it involves these works:

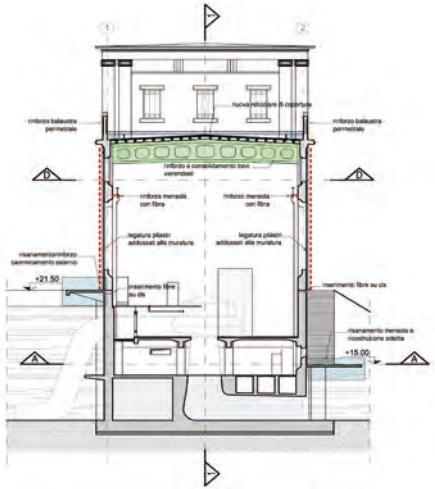
- Reinforcement of masonry parapets on the roof and their anchorage to the roof slab;
- On the roof, introduction over the structural joints of shock-transmitters and shear connections to block relative displacements in transversal direction;
- Over the roof, realization of a plane bracing system made of r.c. beams and steel trusses and rods;
- Ligature of the r.c. pillars placed on the perimeter of the pump room to the adjacent masonry walls with stainless steel bars
- Localized repairing of masonry and concrete cracks;
- Localized reinforcements with FRP stripes.

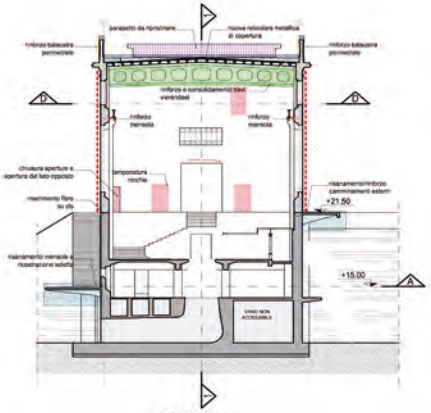


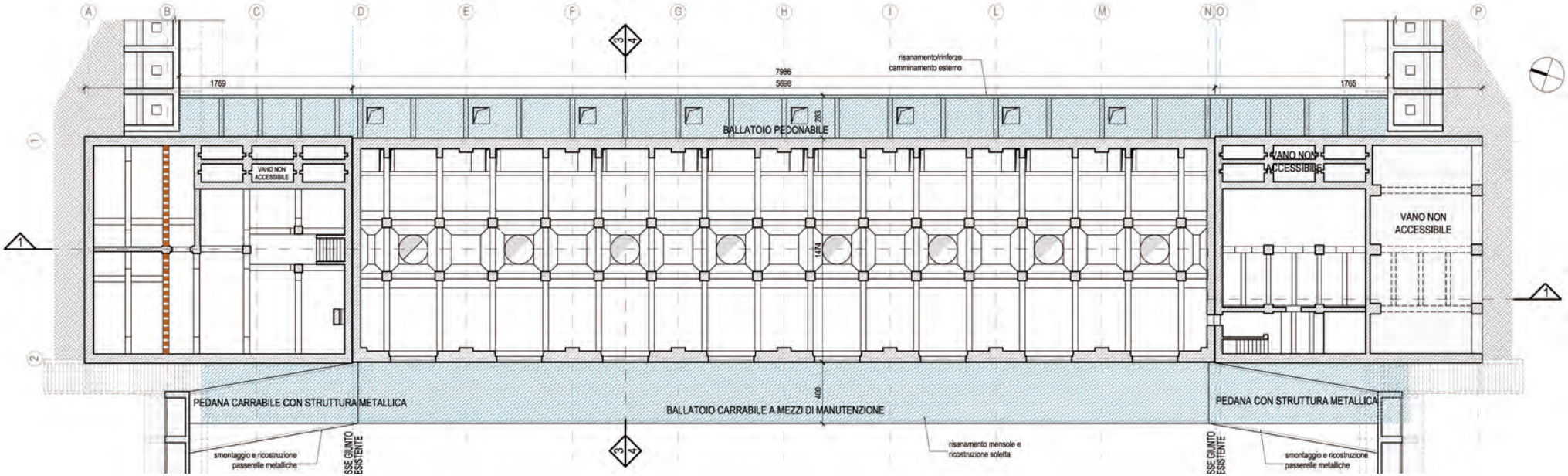
POST SEISMIC REPAIR AND STRENGTHENING INTERVENTIONS


ricostruzione balaustra
rinforzo balaustra perimetrale
consolidamento/rinforzo travi vierendeel
rinforzo pareti d'angolo cabina elettrica
Qv=200 kg/mq
1669
1649
646
798
774
2100
1714
328
511
+17.00
+21.50
+15.00
VANO NON ACCESSIBILE
ASSE GIUNTO ESISTENTE

SEZIONE 1-1






A
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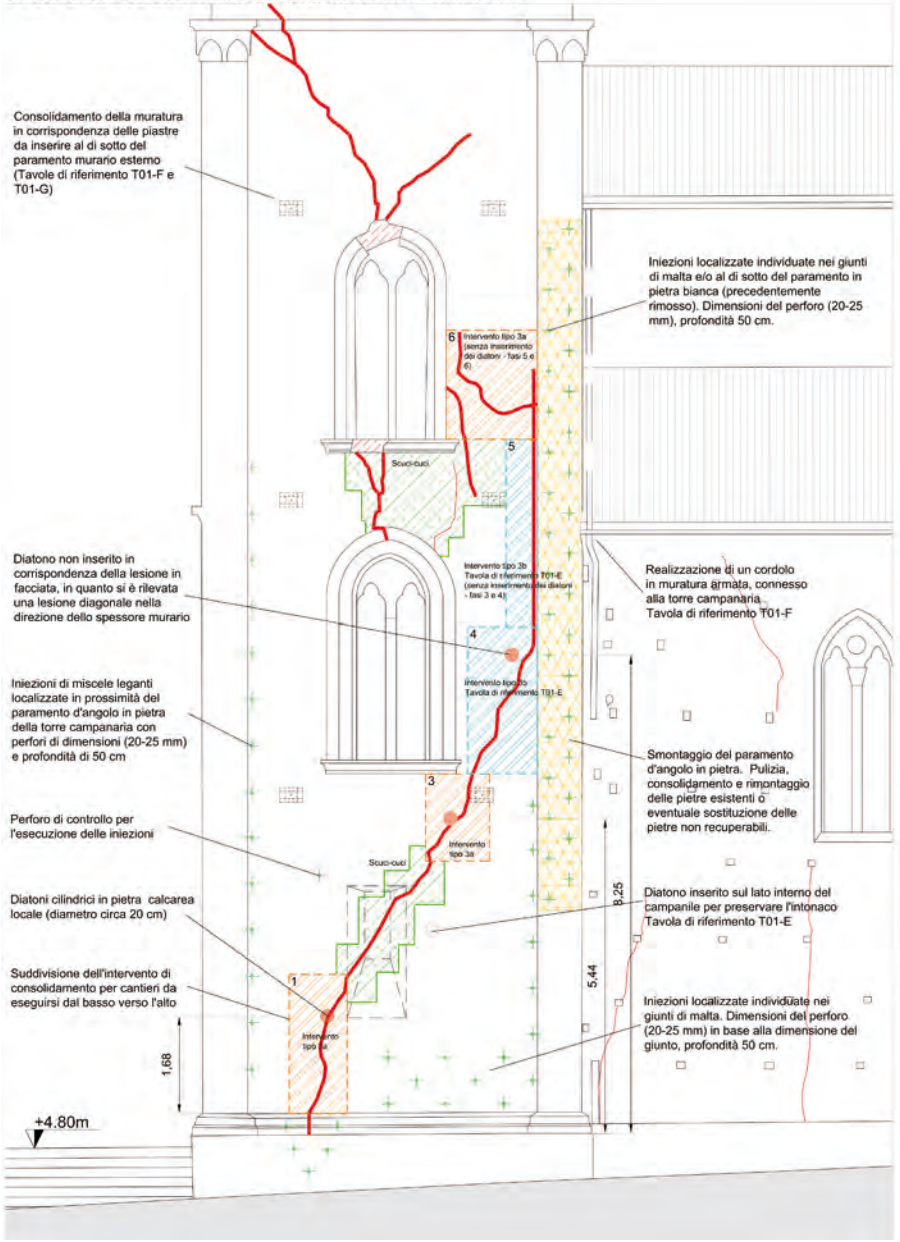
1769
7986
5698
1765
risanamento/rinforzo camminamento esterno
BALLATOIO PEDONABILE
VANO NON ACCESSIBILE
VANO NON ACCESSIBILE
VANO NON ACCESSIBILE
PEDANA CARRABILE CON STRUTTURA METALLICA
BALLATOIO CARRABILE A MEZZI DI MANUTENZIONE
PEDANA CON STRUTTURA METALLICA
smontaggio e ricostruzione passerelle metalliche
risanamento mensole e ricostruzione soletta
smontaggio e ricostruzione passerelle metalliche

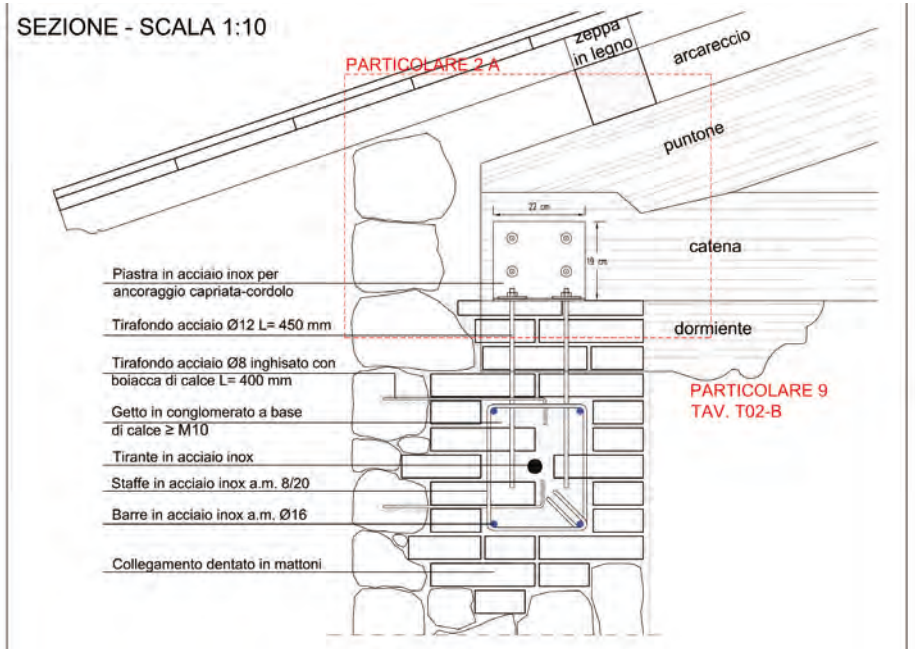
9.2 Restoration and seismic improvement of St. Silvestro's Church in L'Aquila (Italy), 2013

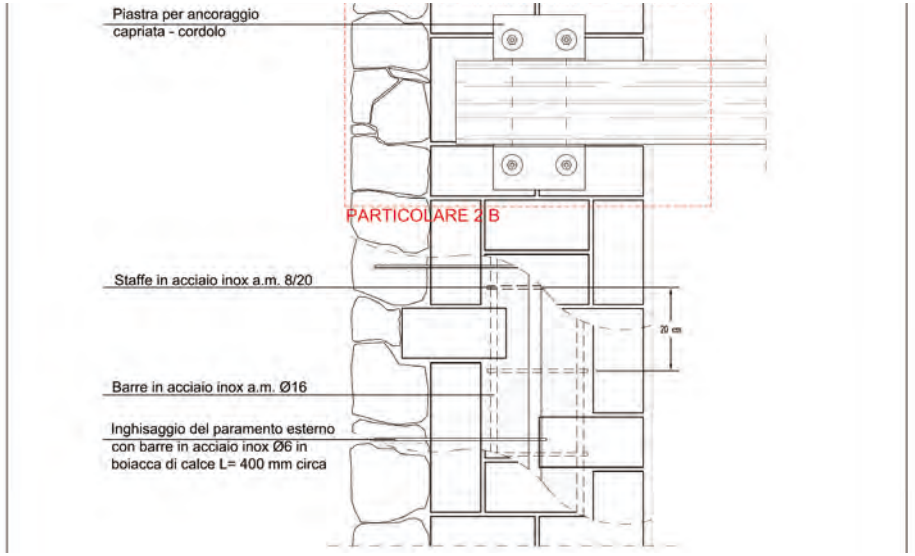
Detailed design and expert advice to the supervision of work
Total construction cost: € 800'000

The church was built in the 14th century in gothic form. In the 15th century the Branconio's family built the Branconio chapel with important decorations and frescoes. After the earthquake of 1703, the church was modified in the baroque style. In the 1967-69 the architect M. Moretti removed all the baroque decorations and restored the severe gothic forms of the church.
The earthquake of April 2009 damaged seriously the structure, in particular the façade and the bell-tower. The main cracks have been repaired with scuci-cuci technique; the original masonry walls realized with the local technique named "apparecchio aquilano" were completely conserved by disassembling localized items and by injecting grout of binding mixtures based on natural hydraulic lime.
The facade is characterized by an asymmetric boundary condition of the higher part, due to the presence of the bell tower in the right side, which prevents the displacement out of plane of the façade. In the left side instead this displacement is unopposed. For this reason, to improve the seismic behavior of the façade and to prevent the overturning, a squared stone buttress has been built on the left side of the façade, connecting it to the lateral wall using steel ties.

PROSPETTO SUD-EST DELLA TORRE CAMPANARIA - SCALA 1:50




SEZIONE - SCALA 1:10
PARTICOLARE 2 A
zeppa in legno
arcareccio
puntone
catena
dormiente
22 cm
16 cm
Piastra in acciaio inox per ancoraggio capriata-cordolo
Tirafondo acciaio Ø12 L= 450 mm
Tirafondo acciaio Ø8 inghisato con boiacca di calce L= 400 mm
Getto in conglomerato a base di calce ≥ M10
Tirante in acciaio inox
Staffe in acciaio inox a.m. 8/20
Barre in acciaio inox a.m. Ø16
Collegamento dentato in mattoni
PARTICOLARE 9
TAV. T02-B


Piastra per ancoraggio capriata - cordolo
PARTICOLARE 2 B
Staffe in acciaio inox a.m. 8/20
20 cm
Barre in acciaio inox a.m. Ø16
Inghisaggio del paramento esterno con barre in acciaio inox Ø6 in boiacca di calce L= 400 mm circa

Damages restoration and seismic improvement of the Cathedral of St. Peter the Apostle after the earthquake of May 2012, Guastalla (Reggio Emilia, Italy)

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St. Stefano di Sessanio's ancient village, L'Aquila (Italy)

Restoration and seismic improvement of the St. Biagio d'Amiterno's Church, L'Aquila (Italy)

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