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Conoscenza, conservazione e valorizzazione
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Indice

Measure and material of the 18th- 20th century masonry techniques. Archaeological analysis of the University building in Cagliari (Italy)[1]

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Abstract

The University building represents a valid benchmark of the 18th century civil architecture in Cagliari. It consists of two separate architectures, initially seat of the Rectorate and of the Tridentine seminary, which over time have taken on a homogeneous character.

The research, facilitated by the realization of a recent restoration project, was aimed to examine the masonry techniques that characterize the building, following an interdisciplinary approach by means of archaeological analyses.

The investigation consisted of two main phases, indirect and direct, carried out in parallel. Specifically, it has been based on a thorough survey of the masonries and on mineralogical and petrographic characterization of the natural and artificial stone materials. The data obtained directly and through experiments were compared with the information found in the archival sources related to the construction phases.

In the context of reference, the contribution is significant to facilitate the recognition, the dating, and the preservation of coeval architectures that, unlike the one examined, are not philologically dated.

opposite page

Fig.1
Cagliari, the Castello district, aerial view from the west, orthophoto 2008, scale 1:2000 (Courtesy of Regione Autonoma della Sardegna)

Introduction

The University building in Cagliari (fig.1-2), built during the second half of the 18th century, represents an excellent chronological benchmark. Actually it is precisely dated, thanks to a series of studies that have already been carried out - including someone very recent (Giannattasio et al., 2015; Schirru, 2010) - based on the consultation of historical documentation, both written and iconographic (fig.3).

The recent restoration project (2013)[2] provided the removal of the plaster and the construction of a new one in some parts of the building. It allowed to investigate masonries directly and to carry out archaeometric analysis. The understanding of the construction process and of the building techniques was facilitated by the critical reading of historical documents related to the construction phase of the 18th to 19th century (fig.4), which put in evidence the differences between the initial architectural drawings and the building effectively realised.

[1] The *Introduction*, *Archaeometric analysis* and the *Conclusion* were written by all the authors; *The architecture*, *The methodology* and *Results-Chronology* were written by C. Giannattasio; *Results-Material* by S.M. Grillo, *Results-Measure* and *masonry techniques* by M.S. Pirisino. The iconographic apparatus was edited by C. Giannattasio; the restitution of the drawings was done by M.S. Pirisino.

[2] This work stems from a convention signed in 2011 between the DICAAR - Department of Civil, Environmental Engineering and Architecture of the University of Cagliari and the Rectorate of the same university, whose object was the "Scientific advice for the restoration of the prospectuses of the Rectorate building of the University of Cagliari". The work was carried out under the direction of Caterina Giannattasio, a multidisciplinary team of researchers of the aforementioned department.
The investigation *in situ* during the building site was carried out by the writers. In particular, Maria Serena Pirisino carried out the activities during the PhD program in Civil Engineering and Architecture of the University of Cagliari, XXIX cycle, in the academic year 2013/2014, with the support of a scholarship financed with the resources allocated by INPS - Management of Public Employees, as part of the initiatives of *Homo Sapiens Sapiens*.

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Specifically, the research has been carried out integrating historical-archaeometrical and scientific methodologies: on the one side, the building has been explored by an architectural point of view, using an approach based on the chrono-typological analysis of masonries, providing their structural aspects and the executive modalities for their setup. Precisely metric and photographic surveys, supported by drawings highlighting the constructive peculiarities were applied (fig.5). On the other side, they have been studied by means of mineralogical-petrographic and geochemical investigation for the characterization of stony elements, plasters and mortars.
Mineralogical and petrographic characterization has been conducted through optical microscopy of standard thin sections and X-ray diffraction (fig.6), while chemical analysis of the binder have been done by X-ray fluorescence in order to define the nature of the mortar (hydraulic or lime mortars). Finally, the data from the direct analysis were compared with the historical ones, obtained through the examination of the archival and historical iconographic sources.
The research aimed at the definition of chrono-typologies for the masonries, with the adoption of new protocols and multidisciplinary diagnostic techniques. This purpose is significant in the Sardinian context, where studies about the masonry techniques are yet poor (Giannattasio, 2008). Without a framework of systematic support, our studies are focused mainly on philologically dated architectures, which allow to identify the masonry construction peculiarities related to a specific moment in history (Giannattasio, 2009).

The architecture

The University building of Cagliari is currently seat of the Rectorate and of the University library. It was built during the second half of the 18th century and represents one of the greatest monuments, for size and architectural meanings, of Castello (Kirova, 1985), the oldest district of Cagliari (fig.1-2). This monument derives from the union of two different buildings (fig.4) The first one, placed on the North side, was built since 1765 as Rectorate. The second one, situated on the South side, was erected in 1771, originally as seat of the Tridentine seminary and currently as seat of the University library, exhibition spaces and administrative offices. It is the result of one of the most significant action of the architectural campaigns in Sardinia (Schirru, 2010), established by the Savoy crown, after the constitution of the Kingdom of Sardinia in the 1720. Actually, the reform of the University of Cagliari achieved the foundation of the new institutional seat; at the same time, the academic renewal and the nationwide program of modernization of the seminars requested a suitable location in Cagliari (Cabras, 1966; Cavallari Murat, 1966; Pescarmona, 1984; Naitza, 1992; Schirru, 2005-2011). So, Saverio Belgrano of Famolasco, military engineer, drew up an architectural drawing for the new University in 1764, and two years later, situated next to it, he designed the Seminary (Cavallari Murat, 1961). In-

Fig.2
The University building seen from different points of view of the historical centre

spired by models of Piemontese architecture, with some constructive variation, it greatly influenced the entire local public and private building production, implementing a renewal of architectural and urban culture.
The façades show a different pattern in relation to their location (fig.4): the East one is characterized by architectural elements of historical and artistic meaning, which are reduced to a simple system of pilasters, closed arches and string courses in correspondence with the West front and become almost non-existent in the façades of the short sides.
The initial phase did not neglect the effect that the new building would have had in the urban historical landscape. Indeed, the aim was not only focused on the architectural details, but to create new points overlooking the city, in line with the trends of those years, and playing with scenic effects, as in many examples of Piedmont architecture. Finally the scenic space for the University building was obtained through the creation of a system given by the perspective sequence atrium-courtyard-portico, achieved in the middle of the building, and for the Tridentine seminary through the roof terrace on the second level. The effect of transparency and continuity between the Castello district and the rest of the city was quickly denied, due to structural problems –that will be later explained– which imposed the closing of the arches.
The construction site of the two buildings were problematic and long, as it is evidenced by several documents written by chief engineers, surveyors and construction managers, who came in succession during the building phases. The long duration and the inexperience of chief engineers about the traditional local material caused from the beginning the formation of numerous cracks on the walls, on the vaults and arches of the upper floors gallery of the two buildings.
The building yard was completed within the second decade of the 20th century, while the two buildings were joint in 1955 - when the Tridentine seminary was acquired by the University - hiding the original constructive dif-

ferences between them. Despite the many interventions, the design of the architectural complex remained essentially unchanged from the time of its foundation, retaining its spatial organization, and the building still now maintains its formal and material peculiarities. These data emerged in the recent restoration works, during which an intensive interdisciplinary investigation was carried out.

Methodology

The protocol of investigation consisted of two main phases: one indirect and the other direct, carried out in parallel. In detail, the indirect phase was based on:

1. the consultation of bibliographic and archival sources, published and unpublished, kept in the State Archives of Cagliari and Turin, in the University of Cagliari Archive and in the Archive of the Superintendent BAPSAE (Architectural, Landscape, Historical Artistic and Ethno-anthropological Assets) for the county of Cagliari and Oristano;
2. the transcription of the historical documents considered significant for the reconstruction of the history of the site, in particular instructions of the designers, bill of quantities and contracts;

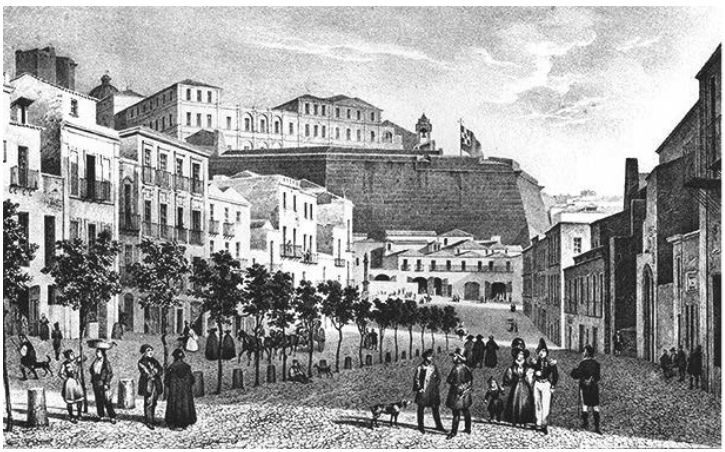


Fig.3
The University building in some historical views of Cagliari: a. engraving of 1832, by G. Cominotti and E. Marchesi (University of Cagliari, Piloni Collection); b. photo taken in 1854 by the French photographer Edouard Delessert, which shows that the Eastern wing of the Tridentine seminary is still incomplete (Sardinian Digital Library); c. image of the late 19th century (Historical Archives of Cagliari, Section IX, Collection and Album, photo n. 498)

3. the analysis of the architectural drawings, of views and of historical iconographic sources (fig.3), essential to the definition of the limits *ante quem* and *post quem*, in the absence of absolute dates;
4. the elaboration of chronological synthesis schemes, both in plan and in elevation, for the external façade (fig.4), which facilitated the knowledge of the several phases of construction;
5. the comparison of the data reported in the archival sources, called "Instructions" of the 18th to the 19th century building yard, with those that emerged directly.

In the direct phase, the procedures conducted were:

1. the updating and revising the 1990's architectural survey, integrated by the drawing of the vaults system in plan (fig.4);
2. the survey and graphics from scratch of the Western courtyard of the building;
3. the image rectification of all the façades, in order to include in the architectural survey the mapping of materials;
4. the image rectification of the Eastern front in the portion immediately above the base and of the Southern part of the Western front, during the phase of removal of plaster referred to the recent restoration project (fig.5);
5. the detailed graphic restitution of the masonry techniques (fig.5);
6. the identification of parts of the masonry not compromised by later interventions back in the first construction phase of the structure and the subsequent selection of masonry samples (fig.5);
7. the analysis of the selected masonry, by means of the study of the techniques, the archaeological survey, the measure and the material of the natural stone elements, bricks and joints, regarding the East façade, as well as the Western front of the former Tridentine seminary;
8. further investigations on the thicknesses of the stony elements for cladding by way of the use of Georadar;
9. the macroscopic analysis and removal of micro-samples, in agreement with the document Nor.Ma.L. 3/80, currently UNI 8458 (fig.5);
10. the mapping of different masonry techniques, in relation to the type of texture, of material and the possible presence of cladding layers (fig.5);
11. the mineralogical-petrographic analysis of samples by optical microscopy and X-ray diffraction (fig.6).

Results

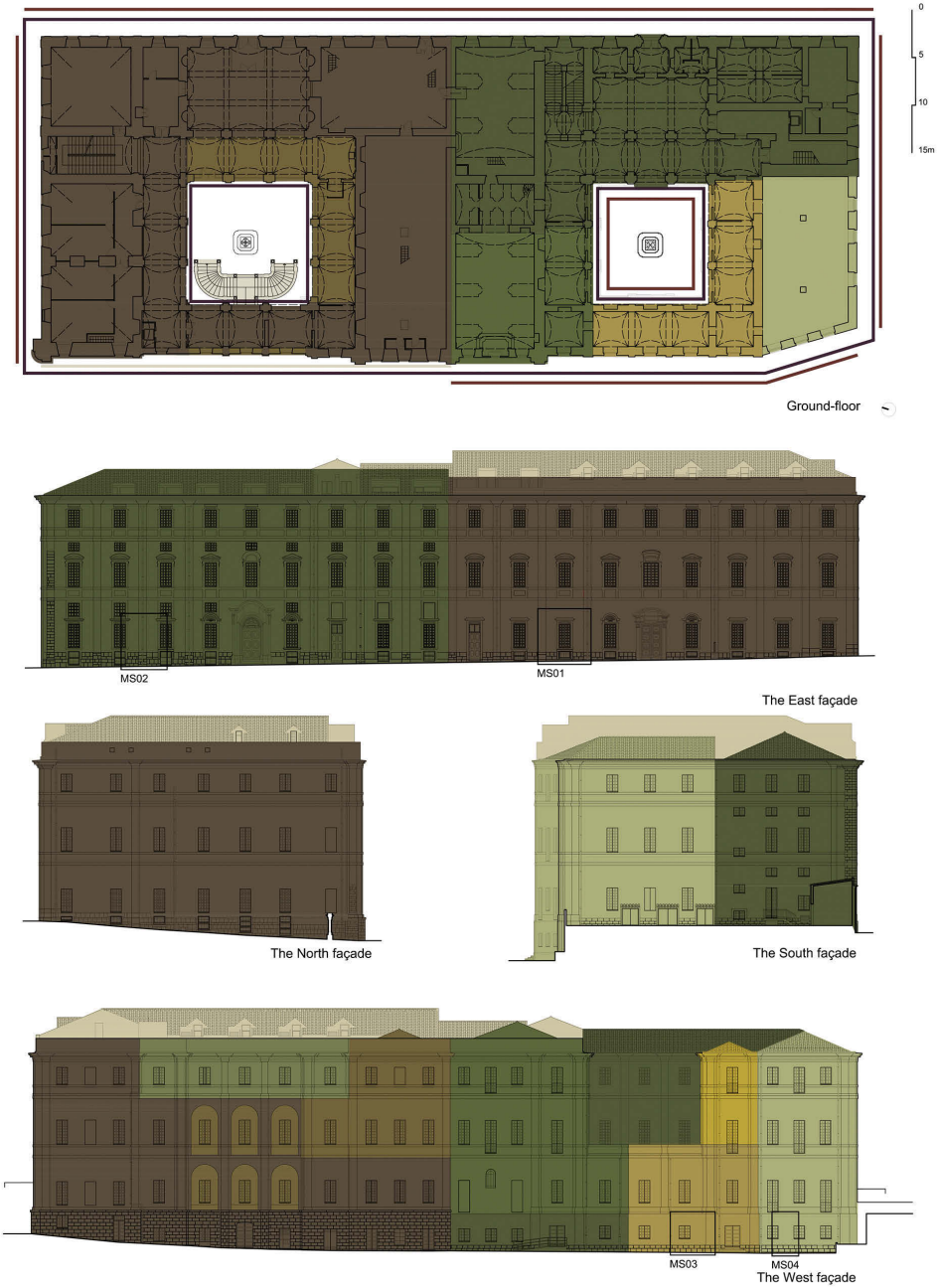
Chronology

The research, as we said before, was carried out through the consultation of bibliographic and archival sources, the examination of the more significant documents, the architectural drawings, views and historical iconographic sources (fig.3). It allowed the elaboration of the synthesis of chronological phases (fig.4), which facilitated the knowledge of the several construction phases.

next page

Fig.4
Synthesis of chronological phases of the ground-floor and of the external façades. In the legend, with reference to each chronological stage, the different symbols show the source through which the relative dates have been deduced. If they are associated not to a precise date, but to a time frame, these symbols are two, and refer to the start and to the end dates. In plan, the interventions of restoration work concerning the façades have been identified with the lines around the building. Also masonry samples, analysed in depth in fig.n.5, have been highlighted with squared frames

Fig.5
Masonry samples concerning the main chronological phases. Each sequence includes: a) the image rectification; b) the scheme of the masonry technique and the cladding typology (M01, M02, M03, M04, M05); c) the archaeological survey; d) a detailed survey of the sample (only for MS03 and MS04).
Mo and Pl abbreviations indicate the sampling points of mortars and plasters which have been the subject of laboratory analysis shown in fig.n. 6

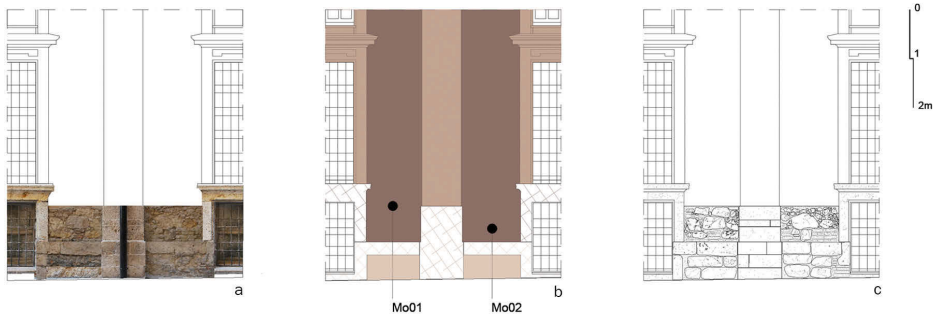

0
5
10
15m
Ground-floor
MS02
MS01
The East façade
The North façade
The South façade
MS03
MS04
The West façade
1765-1769
1771-1777
1777-1832
1780
1781- 1832
1854-1865
End of 19th century
End of 19th century-1921
1928
1960-1965
1977
2014
SOURCE:
ARCHIVAL DOCUMENTS
ICONOGRAPHIC SOURCES
INTERPRETATION BY THE AUTHORS
MS# MASONRY SAMPLES

PHASE 1765-1769

MS01

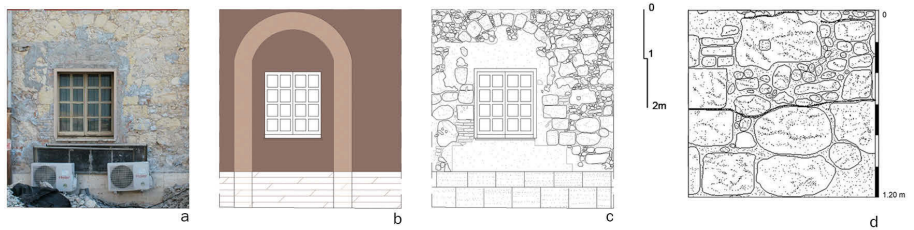
PHASE 1771-1777

MS02



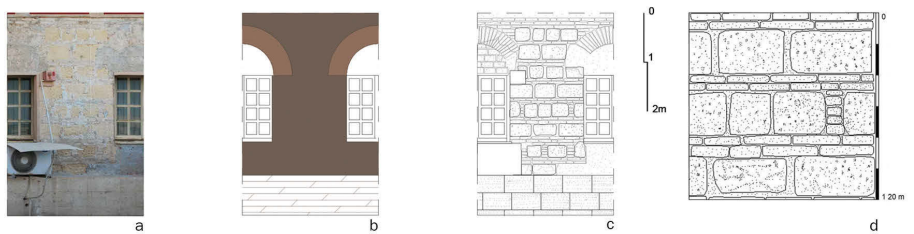
PHASE 1781-1832

MS03



PHASE End of the 19th century-1921

MS04



SQUARED STONE MASONRY

M01 - PIETRA FORTE
- a. Plastered
- b. In view

M02 - PIETRA CANTONE
- a. Plastered
- b. Cladding of Pietra Forte
- c. Cladding of Travertino

ROUGH STONE MASONRY

M03 - LIMESTONE
- a. Plastered
- b. Cladding of Pietra Forte
- c. Cladding of Volcanic Rock
- d. Cladding of Rhyolithe
- e. Cladding of Travertino

REGULAR BRICKWORK

M04 - BRICKS
- a. Plastered
- b. Cladding of Volcanic Rock

EDGED MASONRY

M05 - PIETRA CANTONE AND BRICKS
- a. Plastered
- b. Cladding of Travertino

In particular, we can identify:

a. 1765-1769 (North, West part - with the exception of the top floor, East and ground floor and first floor of the South portion of the University building): the period starts with the beginning of the construction phase in 1764 and it ends with the inauguration of the building in 1769. Both dates have been deduced by archival sources;
b. 1771-1777 (East part and the ground floor of the North portion of the seminary): the dates have been confirmed by the historical documents;
c. 1777-1832 (South wing, the gallery of the East wing and the closing of the arches of the University on the West side): the year 1777 refers to a calculation of spending and completion drawn up, part of archival sources analysed, while 1832 is the date of an engraving in which the building appears to be complete (fig.3a);
d. 1780 (West part of the North wing of the seminary, or the Tridentine chapel and the upper floors to it): the date has been indicated by a document signed by the dean of the seminary;
e. 1781-1832 (South and West wings overlooking the courtyard of the seminary): the first date is the result of an interpretation that starts from the reading of several archival sources from 1777 to 1780, where the priority was to build a chapel and the upper floors to house the seminarians; therefore, the construction of this part should be ascribed to immediately after 1780. The date of 1832 derives once again by the historical view cited in point c;
f. 1854-1865 (top floor of the prospectus on the West façade of the University building): this part is not yet present in a historical photo of 1854 (fig.3b) but it is visible in 1870 (fig.3c) and is also confirmed by a document of 1865;
g. late 19th century (the top two floors of the Southern wing of the courtyard of the seminary): the date has been attested by a historical photo;
h. late 19th century-1921 (South-Western wing of the seminary): the date is inferred from the fact that the portion in question is not visible in the previously mentioned photo of the late 19th century, but it appears in an aerial shot made by a blimp in 1921;
i. 1928 (based on the West façade and staircase in the courtyard of the University): the date has been deduced by historical documents kept in the University of Cagliari Archive;
j. 1960-1965 (the last floor of the University building): as consequence of the acquisition of the seminary by the University (1955), there were several changes an addition to house the University library, all the documents are in the Archive of the Superintendent BAPSAE for the counties of Cagliari and Oristano;
k. 1977 (external façades): the interventions of restoration work, provided documentary evidence, consist in the remake of all historical plasters, the replacement of window frames, the addition of a slab of travertine cladding in the base of the Southern façade and the Western façade of the seminary, as well as the inclusion of shutters in the West side;

l. 2014 (external façades): it represents the last restoration work, which provided for the removal of the plaster and the construction of a new one in some parts of the building.

Material

In the building of the University, the material used, both in form of rough stone or squared ashlars for building masonries and making mortar and plasters, are those from the historic urban quarries. The area where the city of Cagliari stands includes a series of hills consisting mainly of carbonate rocks belonging to the Oligo-Miocene period known locally as *pietra forte* and *pietra cantone* (Grillo, 2009 a).

The *pietra forte* is an organogenic limestone from a very compact cliff, generally white, and it is the most prized lithotype. It has been used mostly for unplastered works, due to its excellent properties that make it particularly resistant to several forms of degradation. The *pietra cantone*, yellow-mustard-cream coloured, on average cemented, slightly resistant to the action of the agents responsible for chemical-physical degradation, was designed almost exclusively for the execution of plastered walls; its easy workability has made it suitable also for the execution of ornamental apparatuses.

The *pietra cantone* has been used for the construction of the masonries and mortars. The *pietra forte*, instead, used only for elements in view, was extracted from a popular site of Cagliari, *Monte Mixi*, known in the 18th century for the extraction of a particularly white material and with very high mechanical properties. Moreover, the building insisted on a *pietra forte* outcropping, so the stone was also recovered *in situ*, and, as described in the archival sources, the excavated material was intended mainly for the execution of the foundational works and rough stone masonry, used for the construction of both buildings. The presence of bricks is also significant, in colours from yellow to cream and light red. They are utilized, both in the University and in the seminary, especially in the construction the vaults. Vulcanites, known in the literature as *trachiti auctorum*, also belonging to the Sardinian lithology (Grillo, 2009b), came from mining sites of volcanic areas of the island. In particular, the two used in the architectural complex are: 1) the trachi-andesites, extracted in the quarries of Serrenti between the end of the 19th and the first half of the 20th century, light grey in colour, widely employed in the architecture of the period of Cagliari (Grillo, 2009a); 2) the rhyolite, with a porphyric structure and well-welded tuff texture, yellow in colour, coming from some sites that are now abandoned, Asuni and the the San Pietro island.

Finally, the travertine, a no-local material, has been used as cladding in some parts of the base of the West and the South side of the seminary palace. Furthermore, the study was supported by mineralogical and petrographic investigations on natural and on artificial stone, in order to characterize the original materials and to highlight the differences with respect to those used in the later stages. With regard to natural stones, having been already widely studied, their characterization was carried out during in-

spections only by way of a detailed analysis. Instead, for brick joints and plaster mortars, a strategic sampling was performed. The micro-samples were subject to:

1. the macroscopic characterization *in situ* and the stereoscopic microscope to define the structure, the degree of cohesion, the porosity, the morphology, the type of fracture;
2. the study of the mineralogical and petrographic thin sections of standard optical microscopy in transmitted light;
3. the analysis in X-ray diffractometry of minced samples in an agate mortar, to define the mineralogical composition and the presence of optically unidentifiable minerals. In order to check whether the samples were actually the original ones, we defined the nature of the components of the aggregate/binder; then we compared them with the formulations of the different mixtures reported regularly in the archival sources.

At present, the investigations carried out on the Eastern façade of the two buildings, in particular the masonry samples MS01 and MS02 (fig.5), confirmed the existence of at least two historical mortars and others attributable to different phases of the construction.

The analysis of samples of historical mortars (M001 and M002) are mostly representative of the 18th century phase of the seminary. In particular, the M001 sample (fig.6) is characterized by a binder of lime and a quartz-feldspathic and bioclastic aggregate, with morphological and dimensional characteristics compatible with the sand coming from the town beach. It represents a historical mortar described in the archival sources.

Sample M002 (fig.6) was collected in the inner part of the masonry. Generally, without a very cohesive cream colour, it is characterized by an aggregate almost absent of fragments of carbonate and a binder of lime from micritic to microsparitic, with numerous appearances of unburned, lime inclusions and shrinkage cracks. Also this category corresponds to the description that is given in the historical documents.

With reference to the plasters, in the East side of the building we can see a succession of plasterwork performed during different interventions.

The innermost layer, corresponding to sample Pl01 (fig.6), is difficult to attribute to a precise moment, but it could be related with the phases of the restoration in 1977. This layer is dark grey, very compact and with a high degree of cohesion with the masonry built with the bricks. Macroscopically, it has the appearance of a cement mortar and its analysis by optical microscopy in part confirms what was observed previously. In fact, it highlightes the presence of a micritic carbonate binder, but with areas characterized by minerals that do not have the same morphology and the calcite colours of interference. The aggregate is quartz-feldspar with lithic fragments of a different nature but mainly granite, with an average particle size, with bimodal granulometric distribution. The presence of shrinkage cracks or unburned was not observed.

Measure and masonry techniques

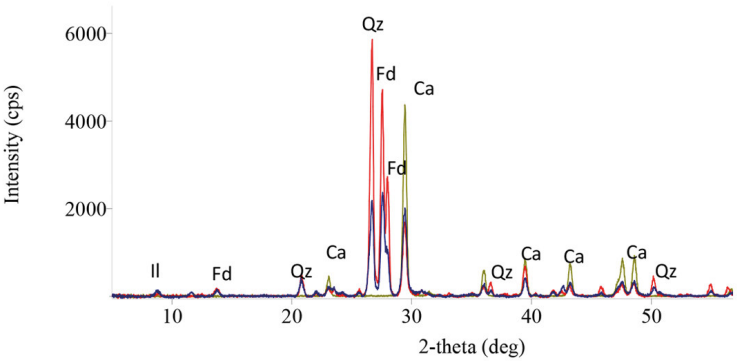
After the definition of the chronological synthesis, several masonry techniques, concerning different chronological phases, have been identified thanks to the removal of plaster from masonries during the last restoration project (fig.4).

The mapping of the different masonry techniques, referred to the ground floor of the Eastern façade of the entire complex and to the base of the Western façade of the seminary, was performed, as previously mentioned, through the analysis of some sections of masonry. They were investigated with the support of drawings at 1:10 scale, through which the constructive peculiarities and the materials in relation to the time of construction were highlighted.

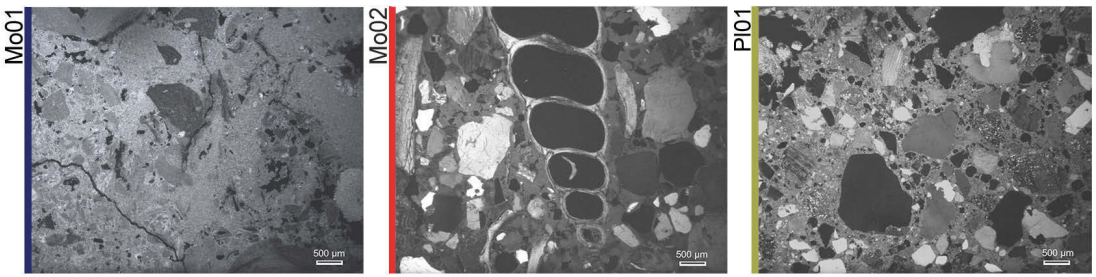
The wall thickness of the investigated structures is generally 1.10 m, but nowadays there is no information about the methods of construction of the section, which could be inferred from archival sources. The absence of this *datum*, certainly significant for chrono-typological purposes, will be further pursued in a later stage by the support of non-destructive geophysical and ultrasonic diagnostic texts.

The thicknesses of the claddings referring to the several masonries were estimated by the surveys with Georadar, giving rise to different measurements depending on the nature of the materials, corresponding to about 50 cm for those made in *pietra forte*, ranging between 20-30 cm for those in volcanic rock and between 4-5 cm for the rhyolites.

Fig.6
Mineralogical and petrographic analysis of mortars (Mo01, Mo02) and plasters (Pl01), carried out by means of thin sections of standard optical microscopy in transmitted light, and by X-ray diffractometry



Qz | Quartz
Fd | Feldspar (Albite-Orthoclase)
Ca | Calcite
Il | Illite



Despite the damage caused by the many changes made over the centuries, it was possible to identify the significant features of the masonry (fig.5).
In summary, these were classified by five types, where the most common is constituted by rough stone masonry, both in *pietra forte* and *cantone*. In this regard, we identified *cantieri*, that is horizontal levels usually realized every 3-5 rows of stones. This technique can not be verified on the East side, due to the scarce height of the part without plaster. Direct information on horizontal alignments can be noticed in the Western façade of the seminary, marked by rough stone masonry punctuated by arches, also *pietra cantone*. The height of the *cantiere*, approximately 55-60 cm, is regulated by that of two squared ashlars used for the adjacent pilasters. In general, measurements of the stony elements, both squared and just roughed, were taken considering the maximum, minimum and prevailing dimensions. With regard to the vertical and joints and horizontal layers, the most common dimensions has been reported. The types detected are the following.
The masonry M01 is squared and realised in *pietra forte*; it is both plastered (M01a) and in natural stone (M01b).
The M01a is used for the portal of the University building and for the base of the Eastern façade of the former seminary. The stony elements, characterized this masonry, have a maximum height of 30 cm, a minimum of 20 cm and 27 cm prevalently; a maximum width of 70 cm, a minimum of 27 cm and 50 cm prevalently. The vertical joints are equal to 1.5 cm and horizontal layiers to about 1 cm.
The M01b is located in correspondence of the cantonal placed in the South-East corner of the former Tridentine seminary and in some parts of the basement of the same building on the Eastern front. These stony elements, well-worked, are positioned respecting the offset of the vertical joints. They have a maximum height of 40 cm, a minimum of 15 cm and 25-26 cm prevalently; a maximum width of 90 cm, a minimum of 20 cm and 50 cm prevalently. The vertical joints are equal to 1-1.5 cm and the layers are quite low (0.5-1 cm thick).
The masonry M02 is built in squared stones of *pietra cantone*. It is located in correspondence of pilasters, arches, architraves and jambs of openings, as well as in the window frames on the side of the seminary on the East façade.
The dimensions of the ashlars change in function of the constructive elements they belong to. In the pilasters, they are arranged in horizontal rows and stacked alternately long ways and short ways, to observe the offset of the vertical joints, with a reduced layer of mortar. They have a maximum height of 34 cm, a minimum of 21 cm and 29-30 cm prevalently; a maximum width of 65 cm, a minimum of 30 cm and 56-58 cm prevalently.
The vertical joints have a thickness of 1-1.5 cm and the horizontal ones equal to 0.5-1 cm. The segments which form the arches have a maximum height of 25 cm, a minimum of 19 cm, 22 cm prevalently; a maximum width of 40 cm, a minimum of 19 cm, and 20-22 cm prevalently. The joints

are equal to 1-1.5 cm. In the openings of the doors and windows are the segments of a maximum height of 45 cm, a minimum of 21 cm and 29-30 cm prevalently; the maximum width is 48 cm, the minimum of 27 cm and the prevalent of 31 cm; the joints are equal to 1 cm.
This masonry is often plastered (M02a), but in correspondence of the basement there is a cladding of different stone materials: on the East side, in the pilasters, it is in *pietra forte* (M02b), while the façade on the West shows travertine slabs (M02c).
The masonry M03 is a rough stone masonry built with limestone (*pietra forte* and *pietra cantone*), of different shapes and sizes. The stony elements are characterized by: a maximum height of 52 cm, a minimum of 19 cm and 25 cm prevalently; a maximum width of 65 cm, a minimum of 22 cm and 48-49 cm prevalently. The vertical joints are 2 cm while horizontal joints amount to 1-2 cm. To fill the interstitial voids, wedges of brick and of stone have been used.
This masonry technique is mainly plastered (M03a). On the Eastern façade of the seminary, in correspondence of the base and window frames on the ground floor, it is covered with *pietra forte* (M03b), while on the same façade of the University building, there is a volcanic rock cladding (M03c) and rhyolite stones (M03d). On the West side, the base of the former Tridentine seminary is marked by a travertine cladding (M03e).
The masonry technique M04 is a regular brickwork, with a size of 5-6 x 25-26 x 14 cm. It is a type used for the pilasters and window frames of the University building, with vertical joints of 0.5-1 cm and horizontal joints of 1-1.5 cm. The pilasters are made with the above mentioned masonry and are plastered (M04a), while the basement has a volcanic rock cladding (M04b).
Finally, the masonry M05 is an edged masonry. It is located along the Western façade of the former Tridentine seminary, corresponding to the last wing built. It is made through the interposition of a row of regular ashlars in *pietra cantone* with two rows of bricks, size 5-6 x 25-35 x 12-14 cm. The stony elements have a maximum height of 37 cm, 20 cm minimum and 25 cm prevalently; a maximum width of 52 cm, 20 cm minimum and 46 cm prevalently. The vertical joints are 2 cm thick and horizontal layers are of 1-2 cm. This brickwork is plastered (M05a), except at the bottom, where it is covered with slabs of travertine (M05b), recently done.

Archaeometric analysis

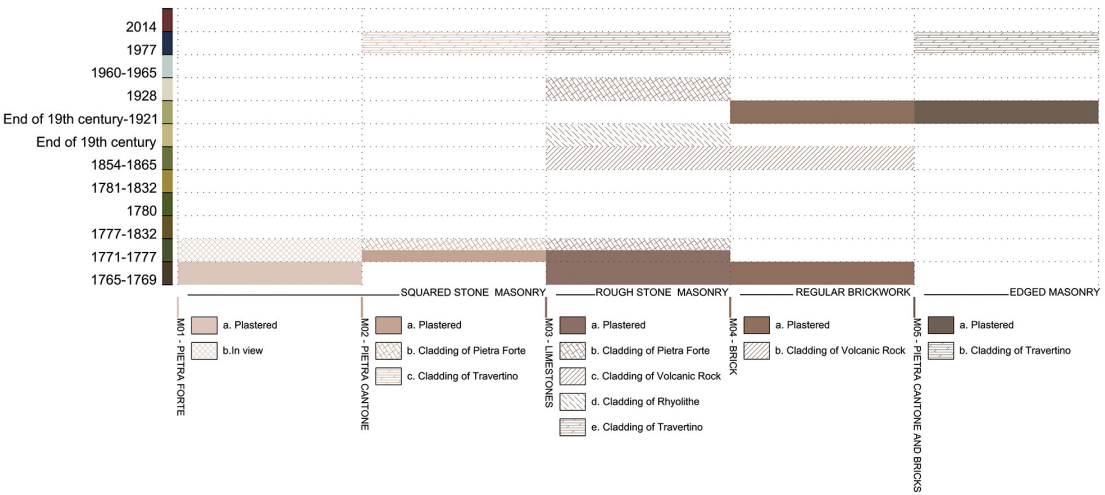
The archaeometric analysis, described in the protocol of the investigation, concerned the most significant masonry samples (figg.4-5), selected following a critical route. The investigation of the masonry samples allowed to underline the historical moments not compromised by later interventions to the phase of the foundation of the two buildings, and also to highlight the differences between the several phases of construction.
Four chronological phases can be summarised (fig.5):
Phase 1 (1765-1769): the sample MS01 regards the construction phase and it

Fig.7
Diagram of synthesis of the relationship between the chronological phases and the different masonry techniques and claddings present in the monument. We can observe that: the squared masonry, both in *pietra forte* (M01) and in *pietra cantone* (M02), has been used from 1771 to 1777, the masonry M02 also refers to the time between 1781 and 1832; the rough masonry (M03) has been used in the period between 1765 and 1832; the bricks masonry technique (M04) has been used at first time in the period between 1765 and 1769 and after in the late 19th and the early 20th centuries; the edged masonry (M05) refers to the late 19th and the early 20th centuries.

is significant as a type of masonry that distinguishes the University building and in detail the pilasters, the basement, window frames and spandrels;
Phase 2 (1771-1777): the sample MS02 corresponds to a section of the masonry of the seminary and summarizes the techniques used for the basement, the pilasters, the masonry, the windows frames;
Phase 3 (1781-1832): the sample MS03 can be associated, for a clear continuity of the style, with the adjacent walls, corresponding to the part dated 1780, and refers to the section of the masonry of the Western façade of the seminary, a system characterized by arches framed by the pilasters;
Phase 4 (End of 19th century): the sample MS04 is dated to the end of the 19th century and illustrates the characteristics of the edged masonry on the Western façade of the South wing of the seminary.
The research findings, related to chronological phases (fig.04), allowed the identification of invariants related to the different historical moments 18th-20th century (fig.7). Synthetically, the rough masonry (M03) was used continuously in the period between 1765 and 1832. The squared masonryM01 was constantly used from 1771 to 1777. The same can be said for squared masonry M02 also utilised to build the equipment characterized by the arches system that marks the West front of the seminary, employed from 1771 to 1832. The use of bricks (M04) is referable both to the period between 1765 and 1769, and the late 19th-early 20th centuries. The edged masonry (M05) refers to the late 19th and the early 20th centuries.

Conclusions

In conclusion, this research exposes the constructive peculiarities in Cagliari concerning the period between the second half of the 18th and the beginning of the 20th century, linking the different project choices, deriving by the Piedmontese culture. Besides, the methodology used represents a reliable tool for the chronological definition of ancient buildings, as well as for improving their conservation management, especially for the



'minor' architectures, whose cultural meaning is often unrecognized. This identification, as we know, is very important nowadays, due to the enlargement of the 'monument' notion, that includes both instances of historical-architectural significance, and traditional urban fabric.
In the future, the purpose is to make a comparison between the mensio-chronological data of the masonries emerged from this research and those concerning other 18th century buildings philologically dated. We will explore, not only the Cagliari hambit, but also other Sardinian areas, characterized by the same lithological and constructive characteristics. With respect to the bricks, we intend to make a comparison with dated architectures present in Sardinia and Piedmont simultaneously.

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