S.M.A.R.T. approach for energy efficiency in Cultural Heritage: the monumental complex of Saint Anthony of Padua.

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ABSTRACT

The restoration project and energy efficiency upgrading of the monumental complex of the Antonian Friars of Caposampiero (PD), spread over an area that contains buildings dating from the fourteenth century, with a total built complex, up to '60s of last century, of more than 8 thousand square meters. The actions of the project are:

1 LaserScan-relief and 3d modelling;
2 Energetic Check-up and modeling of the church and of the new extensions;
3 Energetic regeneration through a new thermal plant system, supported by geothermal and solar technologies;
4 New connecting arm between the monastery and church, made by a new 300 square meters building, with zero CO2 emission, LEED certified, built with x-lam technology and supported by a natural ventilation system.

THE HISTORY OF THE SITE OF THE PROJECT

The complex of the Antonian sanctuaries develops from the 14th century around the role of the sanctuary of the "Noce" and of the Cell of the Vision (Cella della Visione"), the first as a reference to the place that was "*the last home of the saint"* (St. Anthony), the second now set in the larger 19th century structure of the church dedicated to St. John the Baptist. The complex is located to the north of the city of Padua, in the area of the Roman centurial countryside (Fig. 1).

Figure 1. Geographic location

The stratifications which have marked the actual volumetric and distributive configuration of the complex are completed by the convent to the south of the church and the house of spirituality, spaces articulated around the important and large central cloister, up to today an extremely important space in the life of the community and the faithful who gravitate around the monastery.
This place has always been a reference point for the economy and the social fabric of the territorial system of the Padua province in the area of the centuriated countryside. Already in the cartographic representation of 1770 (Fig. 2), wanted by the superintendent of the monasteries of the Padua territory, is evident the complex and articulated establishment of the volumes and the open spaces around the complex.

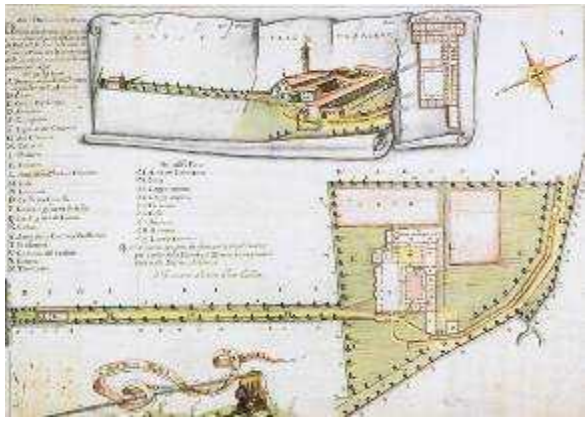

Figure 2. The complex between 1767 and 1769

From the second half of the 19th century various interventions of enlargement and remodulation of the original volumes were realised through important demolition works and the substitution of some buildings (Fig. 3) up to the present structure, that includes the presence of a large central cloister with portico.

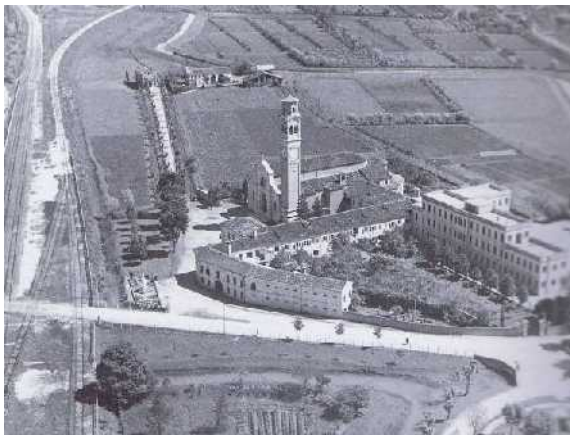

Figure 3. The complex in 1956

Figure 4. The complex in 1994

At the moment, following the last extensions committed in the mid 1990's (Fig. 4), also through the important finances allocated for the works connected to the Jubilee of 2000, the church and the convent occupy a surface of more than eight thousand square metres, in which are present besides three important celebrative chapels in addition to the principal sanctuary, conference rooms with an overall capacity of about 1000 persons and more than one hundred and fifty beds.

THE PROJECT OF ENERGETIC AND ARCHITECTURAL REQUALIFICATION

The project of restoration, functional recovery and extension begun in 2010, concerns an extensive research project which is still in course and is directed to obtain information useful for a precise mapping of the energetic consumption of the complex in order to be able then to intervene with works which will be as far as possible *"cost effective"* as regards a programme that will be realised in a period of three to five years. These necessities have emerged following the problems generated by the works executed in the 1990's (Fig. 5) that have radically disturbed the volumetric configuration in particular of the convent with superstructures and planimetric extensions which have brought to the actual state, without nevertheless caring for essential technical and construction aspects such as: adequate thermal isolation, actions of mitigation of the thermal hygrometric permeability of the walls, containment of heating costs through adequate plant (part of the complex is still heated with systems which date back to the 1960's).

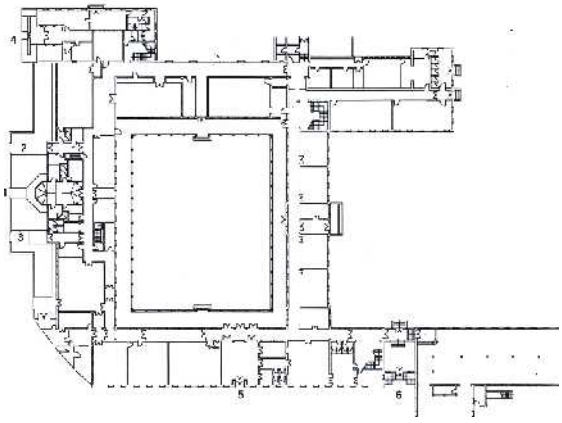

Figure 5. Planimetric extract of the present situation.

The operations implemented to respond to the property owner were orientated from the start on the most imperative priorities in relation to a series of works of ordinary maintenance already under way.
In this paper, for reasons of space, we will deal with three of the four points listed, leaving aside the interventions on the new plant which will be considered in a second phase of the project.

Laserscan planning and three dimensional modelling

A research campaign and graphic reconstruction of the present spatial configuration of the buildings made necessary due to the lack of a detailed succession of plans for the project which was capable of describing the state of the individual buildings in their present distribution and dimension.
In particular, a 3D laser scan has been performed on all the external prospects of the complex and, given the special historical architectonic importance, the internal part of some buildings. The various “clouds of points” acquired this way have been subsequently optimized and “recorded” in just one cloud connected to the data of the preliminary high definition photographic survey.
The “cross” employment of different yet complementary technical-instrumental procedures together with the analysis and direct autoptic evaluation ensure appliable “awareness” can be made readily available for any upcoming restoration, maintenance and valorization interventions of the building complex (Fig. 6,7).

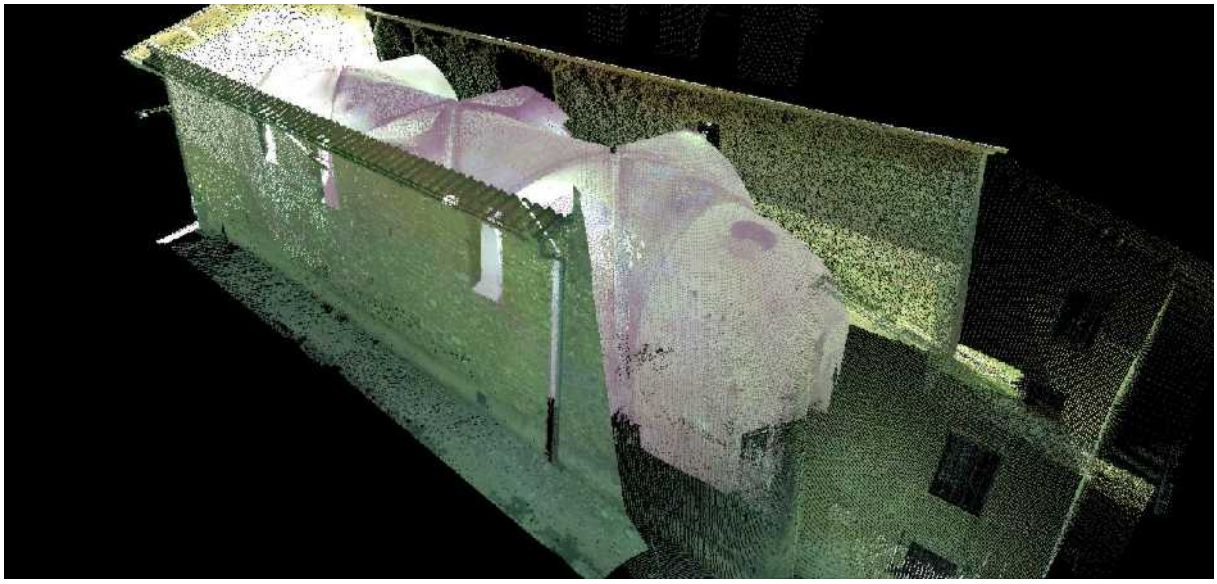

Figure 6. Clouds of points image.

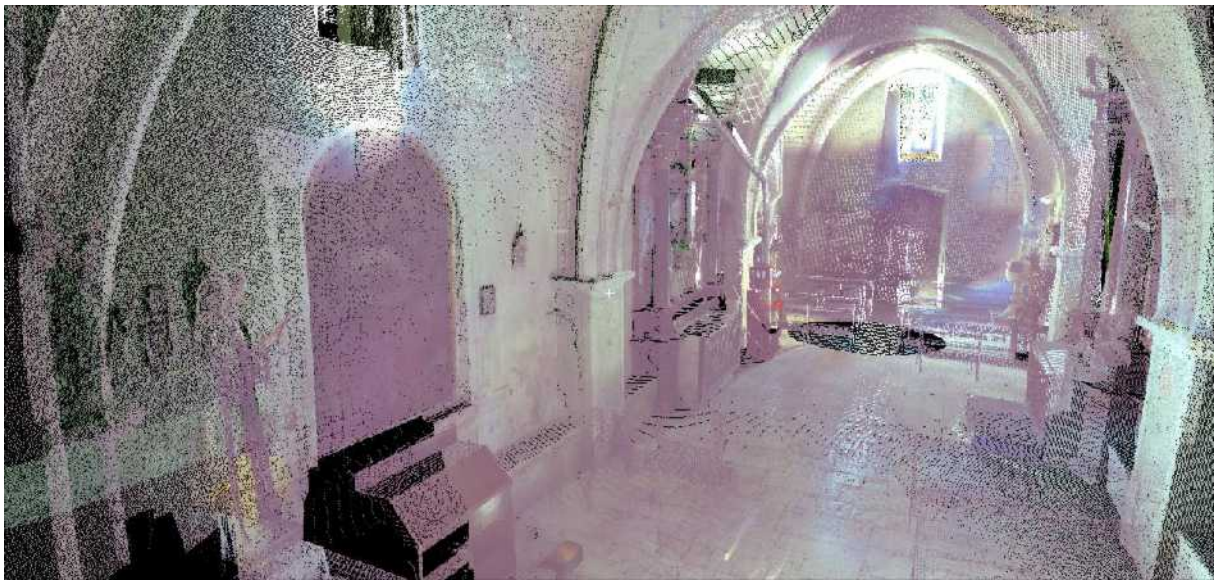

Figure 7. Church interior.

Energetic Check-up and modeling of the church and of the new extensions

The check-up of the present energetic consumption was begun with the scanning of the behaviour of the church of St. John the Baptist to coincide with the works of ordinary maintenance of the zone of the transept and the altar.
Through a mapping executed with thermal hygrometric sensors the thermal behaviour in particular of the transept-altar zone was reconstructed. This area was subject to evident phenomenon of summer overheating for which the use of a system of natural ventilation has been foreseen and which will be implemented in a successive phase.

Methodology utilised. In order to have reliable data as regards the internal temperatures with the variation of the solar hours, were effected the measurements of the temperature using electronic data loggers, instruments that are capable of memorising in Excel format the data of temperature and relative environmental humidity, according to sampling intervals which can be regulated as one pleases (Fig. 6). In the present case time intervals of thirty seconds were implemented (then in the analysis of the data, this interval was increased firstly to ten minutes and then in a successive analysis to an hour, so that the elaboration of the data was simplified). The temperatures and relative humidity were monitored on three successive days (Fig. 8, 9, 10).

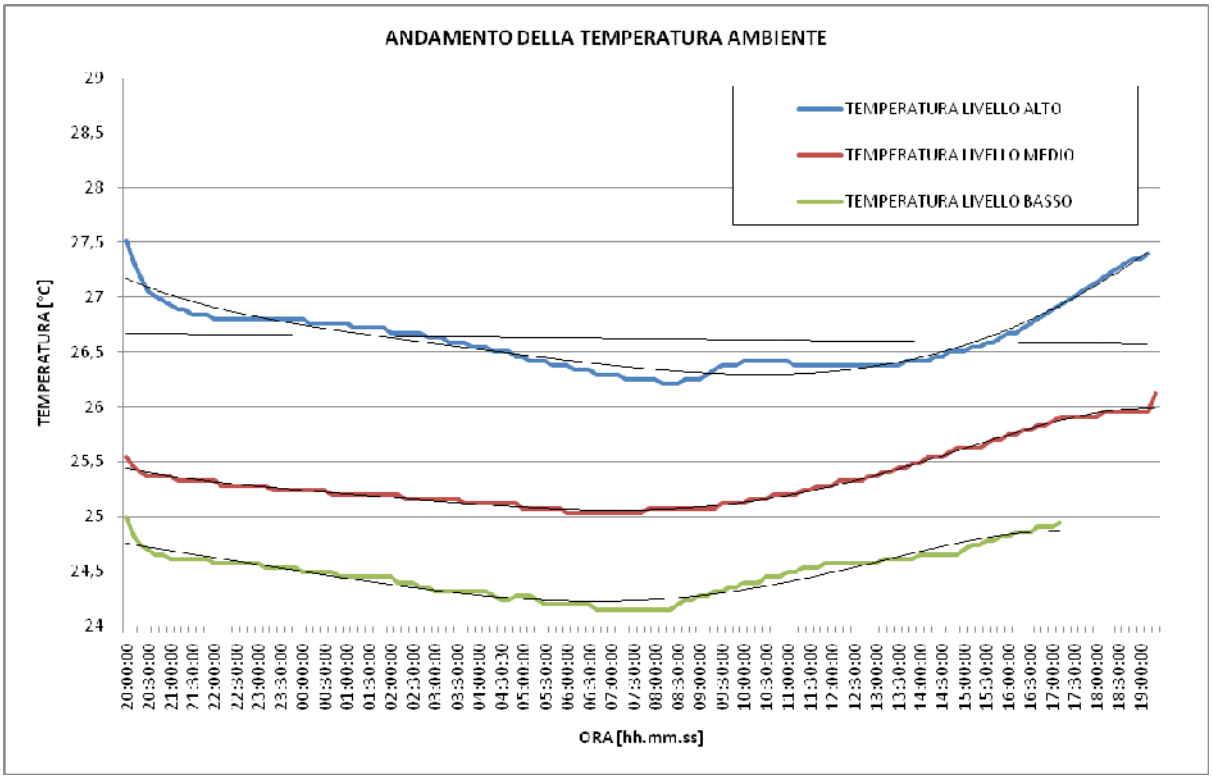

Figure 8. Registered thermal profiles

Once the operative procedure had been finished, we proceeded with the analysis of the data and then evaluated by means of mathematic simulations the effect that the opening of surfaces in the summit of the nave might give to the occupants in terms of comfort.

The next phase after the elaboration of the data collected, was that of drawing from those values, the trend of the thermal loads gravitating on the occupants of the church. In order to consider such values, one needs to analyse the transmission of heat that occurs by means of the opaque and transparent structures to which it is necessary to sum the internal load (which originate from the presence of persons and the environmental illumination). Once known the values of internal and external temperature were extracted the values of the temporal loads, deducing some hypotheses which are briefly summarised here.

Average transmission opaque and transparent structures = 1 Watt/square metre Kelvin;
Total surface with exposure to North=eight hundred and seventy nine square metres;
Total surface with exposure to South=eight hundred and seventy nine square metres;
Total surface with exposure to east = two hundred and forty eight square metres;
Total surface with exposure to west = two hundred and forty eight square metres;
Total surface of roofing = six hundred and ninety square metres
Internal load of illumination = ten thousand watts
Maximum number of persons present = 300

The hypothesis which will be evaluated following the analysis will be that of opening the circular lunettes in the tambour above the altar in order to consent a hot cold downflow in particular during the summer. It is under evaluation also the necessity of

implementing a system air to air which primes the thermal flow with greater control by the users and consequent efficaciousness.

Figure 9. Site prepared for the thermal survey

Figure 10. Phases of planning and graphic restitution in real time.

New connecting wing between the monastery and church, made by a new 300 square meters building, with zero CO2 emission, LEED certified, built with x-lam technology and supported by a natural ventilation system.

The project interests an area of connection between the body of the Church of the "Vision" (Chiesa della Visione) and the Convent. The portion object of restructuring and adaptation through modifications of the internal dividing walls, new floors and partitions will regard an area of about three hundred square metres, in which we will try to realise also a strategy of adaptation of the plant aimed at energy saving in particular during the winter (Fig. 11). The portion which necessitates a small enlargement will constitute the new small hall of the Word ("nuova piccola Aula della Parola") for a surface corresponding to about sixty square metres and a volume of three hundred and fifty cubic metres. This part of the intervention will be obtained by means of the demolition of the ambit of the existing confessionals, that is a space of about two point two metres of width by fourteen metres of length. The average height of the portion, object of the restructuring, will be substantially maintained, except for a lowering

necessary for the new canalisation of the systems. The average height of the new hall, in coherence with the adjacent room, will resume the maximum heights of the existing building.

Figure 11. Area subject to demolition and reconstruction

The proposed project tries to act in a context of the global coherence of the intervention with the surroundings, both under the architectural and functional profile.
The principals on which is based the proposal are the following:

- the differentiated use of the natural illumination in function of the different rooms, in order to underline the passage of the celebrative space and their succession. This is translated for example in the holes diffused in the façade in bricks, in the high glass windows of the courses and in the rooflights of the confessionals (Fig. 13),
- the rearrangement of the flows of access, through transit and stop in accordance with the sacrament of confession,
- adaptation to the needs in terms of accessibility by persons of reduced or absent capacity of mobility,
- new building in X-Lam of high resistance in order to obtain reduced building times and optimum mechanical performance in relation to reduced weight Fig. 12),
- rearrangement of the covering surfaces, according to the solutions of materials more significant in relation to the existing and to a sober contemporary identity. (this will pass through the use of large grain plasters, brick and single stone components),
- systems of natural vertical and transversal ventilation which utilise in gradient of temperature between the floors which generate fluxes of internal air capable of guaranteeing a passive climactic supply in summer regulation,
- system of central heating with recuperators of heat for a system of air to air heating of the new rooms,
- walls in full bricks of high thermal inertia (orientation south-west) capable of acting as a thermal buffer of compensation of the internal temperature during the whole year,
- shape of the confessionals in the form of upside down truncated cone in order to increase the chimney effect in order to achieve a better natural ventilation and to obtain better performances in terms of illumination (Fig. 14).

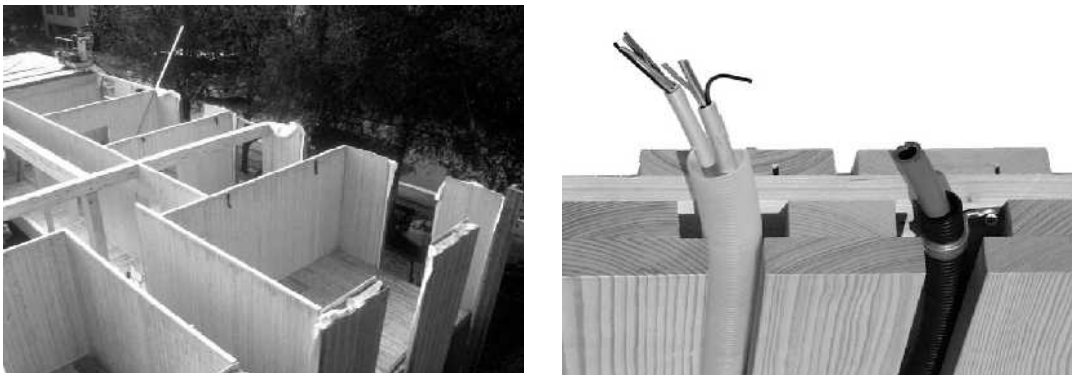

Figure 12. Technology X-Lam

Figure 13. Bioclimactic scheme

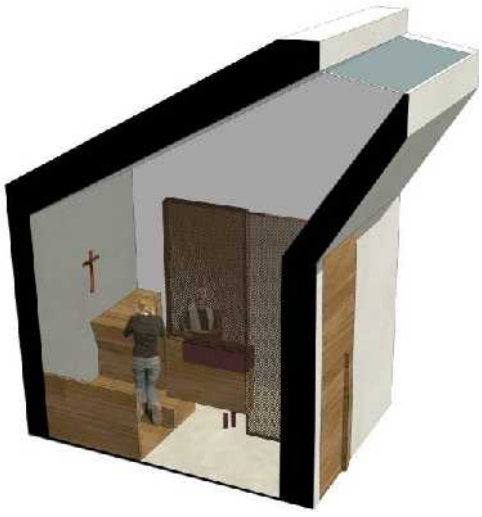

Figure 14. Detail of confessional

Figure 15. View of new body of building with facade in bricks

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