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THE ROLE OF DIAGNOSTICS IN THE RESTORATION PROJECT

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ABSTRACT

Over the last few years, in the field of restoration and conservation, the techniques used to evaluate the extent of damage are becoming increasingly more important before carrying out any work on a historical building. The diagnostic phase is the instrumental, methodological and procedural means of guidance and control during the preliminary cognitive examinations of the building which requires work. For this reason, in the restoration project, the procedural sequence is heavily based to the cognitive phase.
In order to evaluate the conservational state of a structure correctly, it is necessary to understand the symptoms of the degradation and the principal cause. When this correlation is unclear there follows the planning and carrying out of a series of cognitive investigations. There is a preference in using indirectly destructive or non destructive investigative techniques to evaluate the state of the damage and degradation of monuments. These tests, which are carried out in situ, are based on identifying global physical properties present in the walls or the walls' components and provide information about their behaviour. This study presents the planning and implementation of a series of surveys, carried out in situ, preliminary to structural consolidation and redevelopment work on a medieval castle: the castle of Cancellara (South Italy).

KEYWORDS
Diagnostics, Pathologies, Knowledge, Restoration, Non destructive tests.

1. INTRODUCTION

The phase of "knowledge" (or qualification) of a building – which can be historical, linked to materials, technical-constructive, linked to structural and functional modification and changes or to conservation status – represents the indispensable preliminary stage to evaluate its residual performances skills and the right process of a recovery and/or maintenance plan. This knowledge therefore cannot be referable only to the design phase, but to the whole life-cycle of the building [Guida and Mecca 2006]. Only through a fair knowledge of the building, it is possible to check and/or verify the achievements of the looked forward to performance qualities, during execution, and their conservation (or rather obsolescence monitoring) for the whole operating life of the building. Because of the various approaches and research systems, it is necessary to divide the cognitive process in order to optimize times and techniques, checking constantly its correspondence to the actual cognitive necessities of the building, regarding its history, its technical-technological features and its conservation status [Pesanti 2001].
The uncritical or undifferentiated carrying out of cognitive methods and surveys rarely leads to an actual exhaustive knowledge of the building, since it is possible to check easily the superimposition of data which are

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less correlated among them and, anyway, which are not aimed at defining completely the looked forward to set of knowledge for the further development of the plan. For this reason it is necessary to adopt a procedural guide and check methodology of the diagnostic survey which, starting from the identification of a failure state or a pathological and/or degradation state - which can be interpreted symptomatically -, formulates a diagnosis and therefore finds out the fault.
The diagnostics' aim is to reduce pathological phenomena interpretative uncertainty to its lowest terms through an approach fit for rearranging the different specialisms. Suggesting and developing a fair diagnostic campaign becomes indispensable before tackling any restoration interventions in order to gauge first the plan and then the intervention to the actual, objective requirements of the building.

2. THE ROLE OF DIAGNOSTICS IN RESTORATION

Diagnostics applied to cultural property means those pieces of information to be collected so that the cultural property can be object of restoration, conservation and maintenance, or even easily an object of spread and transmission of the property itself for present society and future generations. The idea of diagnostics has evolved step with the idea of restoration. In the past, the restoration intervention was essentially an artistic operation, restorer corresponded to architect/operator called to reconstruct the lost parts of an engineering work.
Nowadays this idea is completely different, because restoration is no longer considered a "reconstructive" restoration, but a conservative one, in which the way to see the flowing of time has changed. While previously everything time had cancelled or changed had to be reconstructed as much as possible similar to the original, nowadays it is inconceivable to restore the original status of the building, because, reconstructing the missing parts, a fake would be created. Therefore an artistic vision of restoration without any technical or scientific basis has been changed by a totally opposed situation, where restorer is not an artist, but someone able to protect the building both technically and scientifically by further damages, to find out the causes of instability and degradation and/or to make the effects less visible. This different vision of restoration has obviously affected diagnostics, which was not so necessary in artistic restoration, where having artistic skills was enough to reconstruct the degraded parts of the work. Diagnostics becomes fundamental in a technical-scientific vision of restoration, where it is necessary to stop a degradation process, to protect the building from an aggressive environment, to know materials, chemical reactions which can happen and damage an object, to know the previously used materials in restoration operations, defining their compatibility with the new ones. This new vision of restoration has certainly contributed to this change in the idea of diagnostics, together with the progressive increase of the instruments at disposal for knowledge and also the use of on average destructive and non destructive diagnostic surveys. In fact, from diagnostics meant as destructive operation belonging to a consolidated tradition from philological restoration's entreaties, in the last few years this disciplinary sector has tended to an increasing development of non destructive techniques, also deriving from experimentations carried out in other scientific fields. These surveys methodologies have had to face initial difficulties because of high costs and the poor direct correlation between non destructive techniques results, generally qualitative, and quantitative parameters of buildings behaviour. These difficulties have been overcome by the increasing number of feasible non destructive surveys and therefore by a suitable correspondence of results, and by the individuation of a coherent theoretical and methodological frame set at the basis of the restoration plan. The approach to individuate a diagnostic methodology develops in two different ways of thinking for the operators' training and therefore for the "*modus operandi*": the cognitive phases approach and the kind of material one. The cognitive phases are divided in knowledge of material, knowledge of building, interpretation of degradation processes, individuation of degradation causes, definition of protection and intervention systems and choice of restoration phases, in order to get nearly complete information about the building, object of intervention. Nowadays achieved knowledge on materials is so specialized to lead to a sort of subdivision of some study, treatment and interpretation techniques, which have become so different from material to material that it is quite impossible to try to maintain homogeneity through phases for the various materials. It ends up by giving an amount of information which often do not lead to fair conclusions, even if elaborated again. Therefore, without omitting the various aspects of the problems which are found in the restoration sector, facing an intervention plan it is necessary to plan a suitable diagnostic methodology, considering the building to be worked on; according to cognitive phases (building, materials, degradations, pathologies) and /or materials; (fair knowledge of pathologies and single materials and their interactions behaviour) [AA.VV. 1999].
The preliminary survey phase should include the survey of constructive techniques, visible anomalies, degradation phenomena and context data. It should be developed in objective and non-interpretative terms. Prefiguring a diagnostic hypothesis during a preliminary survey phase could lead to not pointing out facts which can be evaluated afterwards according to their incidence on a specific pathology. Pre-diagnostic phase is also widely known as a structured processing phase of preliminary information, with the double aim of determining the first diagnostic hypotheses, defining and programming further in situ surveys in order to bear out and justify the aforesaid hypotheses. The diagnostics phase is generally divided into a first experimental survey phase

(samplings and tests) and analithic modelling (quantitative or qualitative) to determine the pathological frame and to formalize the diagnostics in a following phase. Analithic and experimental activities are aimed at better characterizing the knowledge on the working of the object and constituent materials and at understanding the succession of events which lead to degradation. They are aimed at reducing the range of hypotheses matured in pre-diagnostic phase and eventual validation of those remaining hypotheses [Guida and Mecca 2004].

3. APPLICATION IN A RESTORATION PLAN: THE CASTLE OF CANCELLARA

The Municipality of Cancellara[4] has assigned DAPIT/USB[5] and IBAM-CNR[6] the carrying out of cognitive surveys aimed at a closely examination for a restoration intervention of the Castle of Cancellara (fig. 1). Cancellara settlement was already documented in 1189, in fact the village is an example of fortified area dating back to Norman-Sveve age, only after the year one thousand the Feud of Cancellara is documented. Under Angevin rule, Petruccio de Cancellario, the Acciaiolis and the Zurlos followed each other. In the 16th century the feud was property of the Caracciolos from Brienza, then it was continually sold and donated. The origins of the castle are unknown, some historians attribute then to the Normans even though, at that time, the defensive element was probably around the squared tower located in the eastern part of the existing castle. "According to other sources, it is possible to think that until the second half of 1200, when under Frederick II of Swabia the Edicts of Capua were issued, the castle had not been carried out yet […]"[7].

For others, the first plant of the castle dates back to 1300, when it was built by the Acquavivas from Aragon, enlarging a *castrum romano* erected by Pietro de Cancellario. Under the Zurlos rule, when in 1490, among the Baronial properties of Cancellara, the "castrum seu fortilitium" is mentioned, in fact at that time the castle gained a defined shape; it probably showed courtyard, stables and covered rooms [De Fino *et al.* 2005].

The castle is in the heart of the ancient village in dominant strategic position in comparison with the access roads to the town. It is reachable from two concentric paths and it is inaccessible from the South, where there is a difference in height of 40 meters, while it is accessible from the North from a square. It is made up of three levels cores which enclose a quadrangular interior court. To the South it is made up of a rectangular block with considerable volume hardness. To the East a square large tower which is forward in comparison with the facade of the building, presumably the first fortified plant which was enlarged during the Angevin and the Aragonese dominations, while it was changed into baronial palace in 17th and 18th centuries [Rescio 2003]. To the West the castle has got a regular development, with the 17th century insertion of a two levels element, the chapel. In the end, to the North, the layout plan is divided into two projections, a semicircular tower and a thickening in the perimeter wall in the North-East cantonal plan.

Figure 1. The Castle of Cancellara Southern view

Since the rare historical/architectonic value of the Castle of Cancellara from a historical, architectonic and artistic point of view and the presence of static problems, supporting structures conservation, foundation and roofing, the municipal administration, pointed out by the Commission for the Architectural and Landscape Heritage, has required a cognitive surveys campaign. Furthermore the need for an intervention - using suitable and advanced technical-scientific methodologies from a point of view of effectiveness and compatibility with the monument's historical and cultural values – has persuaded operators to adopt little destructive and non destructive techniques and surveys.

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[6] National Research Council Institution for Archaeological and Cultural Property, operational unit in Potenza
[7] De Fino, Guida, Guida, Fatiguso, *Il Castello di Cancellara. Castrum seu fortilitium*, Ermes, Potenza 2005, pag 20

The results of the surveys cognitive and diagnostic campaign should be functional to the formulation of the diagnosis of the degradation pathologies and to the development of planning choices regarding technologies to use and precautions to take in the intervention phases. Thus the adopted diagnostic/cognitive programme has seen the carrying out of some tests and surveys which have concerned the whole architectonic complex and others which have concerned its southern wing.

4. THE CARRIED OUT TESTS

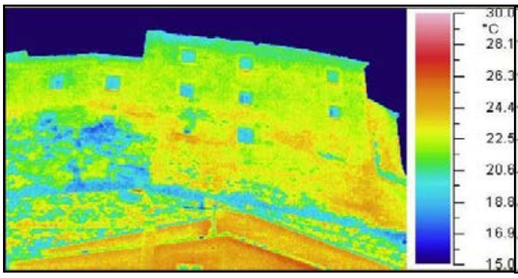
The carried out surveys and tests are the following:

1. Passive thermographic surveys aimed at checking the wall texture, the presence of different materials, some structural pre-existences and eventual constructive anomalies, discontinuities, damages, cavities, plaster removal, conservation status of the surfaces, capillary rise and infiltration moisture;
2. Sonic tests on masonry aimed at characterizing quantitatively materials from the point of view of their homogeneity, hardness and rigidity, and to find out eventual fractures and discontinuities;
3. Ultrasonic tests on natural homogeneous stone materials relating to the keystones of the portals and decorative motifs.
4. Penetrometric tests on mortars aimed at mechanic characterization and analysis of the degradation status;
5. Mineralogical-petrographic and physical analysis of inert stone materials, mortars and plasters, aimed at their characterization and qualification of their degradation;
6. Weight-measurements of mortars moisture content;
7. Study of constructive techniques, analysis of building phases and anamnesis of the restorations;
8. Degradation analysis and an overall systematic description of the cracks occurred.

The carried out diagnostic analysis has given significant achievements in the following described tests.

4.1 Thermographic surveys

The thermographic surveys have been carried out using an AVIO TVS-600 microbolometric thermocamera which works in the “long wave” spectral bands between 8 and 10 micron. The surveys have been carried out both inside and outside the castle. The surveys inside the castle have concerned in particular a ground-floor room affected by infiltrations and rising moisture problems and two rooms with frescoed barrel lunette vault at the first floor. In the first case, thermography has been used in order to determine the water rise, the presence of salts and the connected phenomena of plasters and masonries degradation. In the second case, it has been tried to evaluate walls and vaults’ building typology, the presence of cracks, solutions of continuity, removals and swelling of the different plaster layers. The outside thermographic surveys have affected the facades of the castle, whose exposure to solar radiation has been previously analyzed in the course of the day. The prospecting charts have been carried out non-stop, starting from the absence of solar radiation, from the early afternoon to the first evening hours. Shots have been done with a temperature range lower than 15 degrees C and they have concerned the whole inside surface of the facades. The particular conformation of the places has allowed the carrying out of a thermal photo mosaic only on the southern facade, after having processed the single thermograms and having taken them back to the same temperature and emissivity parameters, in order to have a global and comparable thermal vision on the whole facade. On the southern facade, the thermograms’ precise analysis has pointed out different thermal emissivity of the facade’s parts. In fact every thermogram attests a temperature decrease from the low to the high due to, on the one hand, the presence of a batter in the basement and therefore to a greater radiation of the keystones. On the other hand, this is due to the different thickness of the outside walls which reduce the walls’ thermal inertia, little by little rising to the top. Furthermore, it is possible to observe how the part of masonry under the roof is much colder than the rest, because of the presence of airing holes in the eastern area of the facade and the presence of a concrete kerb in the western part (fig. 2).



Filename :	01010078.IRI
Date :	25.05.2007
Time :	20:00:00
Max. temp :	31.14
Min. temp :	9.04
Amb. Temp :	28.10
Sensitivity :	0.09
Emissivity :	0.95

Figure 2. Outside Thermogram Southern view

For the northern facade, the shots have been carried out from the bottom and they are accompanied by digital photos for a short visual comparison. Then the thermal images have been processed, on the same emissivity, with the same temperature range and compared, to get qualitative information on the materials of the facade and their degradation. In the part of the facade included between the towers, different geomaterials are pointed out. They make up the vertical masonry in comparison with finishing materials, slabs, angles and also wooden flanges which are hotter (fig. 3).

Figure 3. Outside Thermogram Northern view

4.2 Sonic tests on facing panels

The sonic surveys technique is based on the production of elastic waves, within sonic and ultrasonic frequencies in a point of the structure, through the percussion either with instruments or electrodynamic transducers. The data processing, on the contrary, lies in the calculation of crossing time and speed of the impulse given to the masonry. The used instrument is the Boviar's CMS-PC Ultrasonic System which is able to measure propagation time of the elastic waves within the materials and to view the real wave's shape of the acquired signal on a PC, checking the quality of the signal.

Sonic tests have been aimed at acquiring values in order to draw qualitative information on the mechanic behaviour of the masonries. For this reason, it interesting to underline that an adequate literature on stone masonry is available in order to interpret data even according to mechanic parameters. In order to define the different status of the masonries, it is useful to refer to four different levels of speed variation field, crossed for stone and/or brick masonries.

1. Speed < 1000 m/s identifies low-quality masonries.
2. 1000 m/s<Speed<1500 m/s identifies masonries with hardly acceptable strength features.
3. 1500 m/s<Speed<2000 m/s identifies masonries with quite good resistance features.
4. Speed>2000 m/s identifies carefully built and well-preserved masonries with good compression strength, evaluated between 5 and 15 MPa.

Both direct and indirect sonic tests have been carried out. On facing panels, where transparency tests have been carried out, the values of average speeds are very variable and anyway they do not overcome 1500 m/s. In some cases – P2P and P8T tests – they are actually below 1000 m/s. The coefficient of variation inside every examined panel is highly variable, in order to prove that there is a remarkable data loss and therefore the facing panel is not homogeneous. Only the P1P panel presents an average value of the elastic wave speed higher than 1500 m/s, in order to prove what aforesaid, it presents the highest value (34.98%) of the coefficient of variation among the tests and therefore the high value of the average speed is not trustworthy (fig. 4). Indirect tests also show the poor quality of the masonry, since they also present average speeds included between 1260.47 m/s and 2116.75 m/s with minimum values recorded for P2P and P3P panels respectively 426.30 m/s and 562.30 m/s and coefficients of variation included between 82.42% and 76.44%.

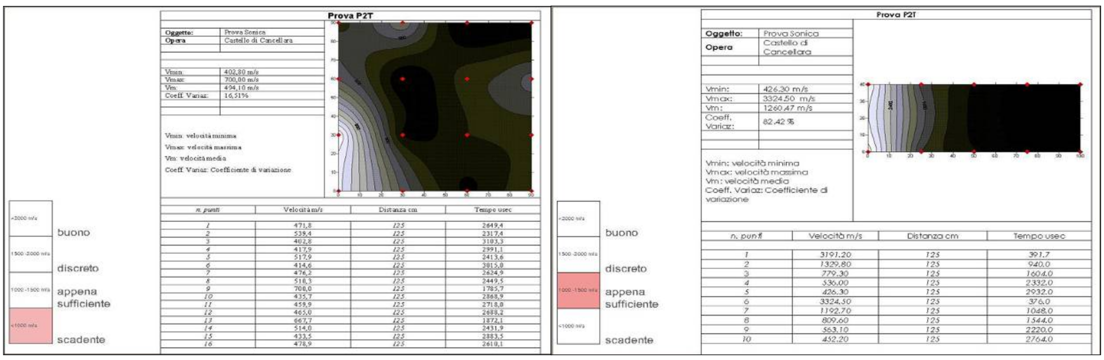


Figure 4. Direct and indirect sonic survey on panel

4.3 Penetrometric tests

The mechanic features of the masonry are deeply affected by the properties of the mortar, especially when, very common in historical buildings, the wall texture is made up of shapeless stones with a small mesh degree. In order to get a fair knowledge of the properties of the material, therefore, the mortar strength evaluation becomes very important. The situation on tests which can be carried out in situ on buildings do not count running and reliable methods in order to determine the mortar strength. Mechanic tests, carried out using flat jacks, are reliable but very invasive, expensive and therefore applicable in a few points of the structure. For this reason, in the present case, since it has been necessary to carry out a great deal of tests on different facing panels, a new penetrometric test has been used. It allows to quantify the mechanic features of the mortar through the material micro-destruction. The penetrometric test allows to determine historical mortars mechanic features of existing buildings, reading the penetration of a steel point driven in the mortar joint. It is carried out in order to correlate the number of strokes per Penetration Unit (SPU) with the mortars mechanic features, the vertical compression status and the mortars joints height [Mecca 2006].
The test has been carried out on different facing panels. Ten perforations have been carried out on each panel, in order to evaluate the SPU value, in order to reach an at least 40 mm driving of the point and the perceptual coefficient of variation (CV) value. The SPUs values have been turned out to be included between 0.92 mm and 0.34 mm with coefficients of variation inside the single mortar joint included between 11% and 33%. These SPU values, compared with the results deriving from other surveys campaigns on historical interest buildings, are considered very low, most of all for those facing panels where the SPU value maintains below 0.50 mm. In specific cases and precisely the facing panels called P1T, P4S (fig. 5), low coefficient of variation values (11% e 19%) link to low SPU values (0.34 mm and 0.47 mm) and this shows how the whole examined facing panel presents an almost completely pulverulent mortar. Even the other examined joints are resistant to the penetration only at the surface layer, though showing a slightly higher SPU value and therefore it is possible to conclude that it is a masonry where the mortar is almost completely decohesive and friable.

n. prova	Denominazione	Rif.	N. colpi	Infissione (mm)	SPU	SPU medio	COV SPU %	[illegible]	[illegible]	[illegible]	Note
		1	13	46,00	0,28	0,34	11%				
		2	17	43,10	0,39						
		3	15	46,10	0,33						
		4	16	42,60	0,38						
1	prova P1T	5	14	45,20	0,31						
		6	16	46,00	0,35						
		7	15	48,00	0,31						
		8	17	45,50	0,37						
		9	14	43,00	0,33						
		10	13	42,10	0,31						

n. prova	Denominazione	Rif.	N. colpi	Infissione (mm)	SPU	SPU medio	COV SPU %	[illegible]	[illegible]	[illegible]	Note
		1	15	41,65	0,36	0,47	19%				
		2	16	42,10	0,36						
		3	25	43,35	0,58						
		4	24	41,10	0,58						
4	prova P4S	5	19	42,10	0,45						
		6	22	40,30	0,55						
		7	22	45,70	0,48						
		8	21	42,20	0,50						
		9	16	44,50	0,36						
		10	20	45,15	0,44						


Figure 5. Penetrometric Test on PT1 and PS4 facing panels

4.4 Mineralogic-petrographic analysis

4.4.1.Mineralogic-petrographic characterization of mortars
Mortars and stones samples taken from the masonries of the castle have been subjected to a mineralogic-petrographic study. Thin sections have been taken for mineralogic-petrographic characterization for optical microscopy in transmitted light observations. Furthermore, for the characterization of mortars, it has been made the separation of the linking fraction from the aggregate one, the reduction and determination of the same mineralogic composition of the binder, through X-ray diffractometry analysis. The diffractometric analyses on the linking binder have pointed out that the analyzed samples are made up of air lime mortars. From a mineralogic-petrographic point a view, or on the basis of the binder textural features, the aggregate grading and nature, the binder/aggregate relationship, the various observed samples present some differences. In particular, CCA1, CCA10, CCA11 and CCA25 samples mortars are characterized by a lime binder with micritic texture, colloform structure and presence of clots. The aggregate is made up of sand having a variable grading from very thin arenaceous stones to coarse grained arenaceous stones (80-1200 µm), which is made up of quartz-arenitic lithic fragments, single crystals, quartz polycrystallines and feldspars. The binder/aggregate relationship is 2:1.

CA26 and CCA27 samples mortars present a lime binder with a micritic texture and an aggregate having variable dimensions from very thin arenaceous stones to coarse grained arenaceous stones (80-600µm) and made up of quartz and feldspars, both as single crystals and polycrystalline aggregates. The binder/aggregate relationship is 2:1.
CCA7, CCA8, CCA9 samples are different from the previously described samples and also different among them.
CCA7 sample presents an aggregate which has got a nature similar to that found in CCA26 and CCA27 samples, or made up of quartz and feldspars, both as single crystals and polycrystalline aggregates, but it is different from them for its lower level of classification and binder lower content (binder/aggregate relationship is 1:1).
CCA8 sample is made up of a heterogeneous mortar, with a carbonate composition binder, with microsparitic texture and presence of coarse clots. The aggregate, quite well classified, is made up of quartz and feldspars; secondly there are also mica fragments and sometimes straw filaments. The aggregate dimensions change from 80 to 600µm and therefore they are part of the arenaceous classes which include from very thin to coarse arenaceous stone. The binder/aggregate relationship is 3:1.
CCA9 sample also presents a lime binder, with micritic texture, sometimes microsparitic. It is different from the other samples because of the nature of the aggregate, which is made up of a silicatic fraction (quartz grains and feldspars) and a carbonate, given by lithic fragments. Its dimensions change from very thin to very coarse arenareous stones (80-1140µm). The binder/aggregate relationship is 2:1..
Finally, from the mineralogic-petrographic study carried out on the mortars of the castle masonries it can be deduced that the mortars in every analyzed samples are traditional lime mortars. On the basis of observations of thin sections on samples coming from both ground-floor masonries and first floor masonries, different types of mortars have been identified. They are probably referable to different periods of carrying out.

4.4.2 Stone elements minero-petrographic characterization.
From the mineralogic-petrographic observations for optical microscopy in transmitted light it has been turned out that stone materials used to carry out architectonic and decorative motifs are made up of calcarenites and sandstones, whose inside different lithotypes have been identified.
The stones of the main portal (CCA6 sample), those of the inner courtyard portal (CCA2 sample) and those of the shelf support at the basis of the inner courtyard staircase (CCA3 sample) are compact detritical calcarenites, which can be classified as grainstones, made up of fossil remains and calcareous lithoclasts. In their inside they are different according to the relationships among the different constituents, the grading and the level of compactation and recrystallization.
Two further kinds of sandstone are identified next to such “calcarenite” materials. The portal near the walls (CCA5) greyish sandstone - which is very similar to the one of the shelves on the right of the same portal - is a lithic calcarenite, while the yellowish sandstone – making up torus molding (CCA4) and probably arches and shelves at the top of the walls – is a quartz sandstone.

5. COMPARISON AMONG THE RESULTS

At the end of the diagnostic surveys carried out on 10 facing panels of the Castle of Cancellara - whose four surveys carried out on the ground floor, one on the mezzanine floor and five in the southern wing of the upper floor – some synthesis cards have been recorded in order to correlate the observations carried out at sight using the metric and typologic analysis of the examined panel with its material features and with the response to the sonic stresses. The comparison has been possible having selected some panels on which comparative surveys have been carried out, on different walls of 1m x 1m, showing the wall surface after having removed the plaster, measuring the thickness – except for the retaining wall panel - and therefore carrying out the different kinds of surveys.
Minimum and maximum dimensions of the stone keystones, dimensional relationships of every single keystone and the mortars joints distribution in percentage within the panel have been pointed out through the metric survey. The single keystones level of working and related percentage, mortars joints percentage regarding their whole surface, dimensions and thicknesses have been pointed out through the metric survey. Furthermore the main breaking guides horizontally and vertically have been identified, aiming at providing a complete typologic classification of the masonry, in order to correlate it with objective values deriving from sonic surveys, with the minero-petrographic characterization and the mortar penetration strength. A further aim of the survey has been to assume or confirm the constructive phases of the castle building site, trying to get some responses from the materials and the constructive techniques used for every facing panel, and therefore, in some ways, to be able to date the masonry or to suit some building sites chronologically.
To classify the examined masonries, according to the provisions of the OPCM 3431 of 2005 (Technical Laws for Planning, Evaluation and Seismic Adaptation of the Buildings), the carried out surveys can be classified as limited in situ surveys, even though the visual exams of the wall surface are very exhaustive, as well as the

evaluation of mortar compactness, achieved after laboratory analyses. Furthermore to complete the level of knowledge about masonries, some direct and indirect sonic tests and penetrometric tests have been carried out. The values of average speed gained by sonic tests have been determined for E linear elasticity module calculation. E_{min} and E_{max} elasticity module scheduled values (corresponding to a masonry class which has been taken as corresponding to the analyzed one) have been used to achieve, through linear interpolation, the real values of crushing and shear strength of the masonry. These latter have been considered reliable when they were less than the minimum scheduled limit. On the contrary, if they have been higher than the maximum scheduled values, it has been chosen to use the latter, to advantage of safety.

6. CONCLUSIONS

The comparative check carried out among the diagnostic tests, even though as far as one wing of the castle, allow us to maintain without any doubt that this is the most desiderable way in any restoration intervention. The diagnostic campaign in Cancellara will have to go on with further cognitive surveys, already planned.
The perspectives of the present experimental research aim at confirming the achievement of a quantitative instrumental approach in the preliminary phases of a monument analysis.
The restoration diagnostics has to be able to get a pre-eminent importance in technical-economic approaches for the evaluation of the activities to be undertaken for conservation, increase in value and safeguard of a cultural architectonic asset.

REFERENCES

Rescio, P., *Basilicata terra di castelli*, Istituto Banco di Napoli, Napoli 2003

De Fino,C., Guida, A., Guida, F., Fatiguso, F., *Il Castello di Cancellara. Castrum seu fortilitium*, Ermes, Potenza 2005

AA.VV., *Manuale per la riabilitazione e la ricostruzione postsisma degli edifici*, Guerrieri F. (a cura di), DEI, Roma, 1999

Pesanti, S., (a cura di), *Il progetto di conservazione: linee metodologiche per le analisi preliminari, l'intervento, il controllo di efficacia*, Alinea Editrice, Firenze 2001

Guida, A., Mecca, I., *A methodological approach for the durability of the recovery interventions* in CONSTRUCTION IN THE XXI CENTURY: LOCAL AND GLOBAL CHALLENGES edited by Roberto Pietroforte, Enrico De Angelis, Francesco Polverino JOINT 2006 CIB W065/W055/W086 INTERNATIONAL SYMPOSIUM PROCEEDINGS – October 18-20, 2006 Rome, Italy, ISBN 88-495-1339-9 e CD-rom Edizioni Scientifiche Italiane ESI 07, by Edizioni Scientifiche Italiane, 2006 Napoli

Guida, A., Mecca, I., *"The durability of the Recovery Interventions Aiming to the Planned Maintenance."* ISBN 88-8443-070-4, e ISBN CD-rom 88-8443-071-2 in Atti del Convegno XXXII IAHS World Congress "Sustanability of the Housing Projects" – University of Trento – Laboratory of Building Design – Trento – Italy – 21 - 25 settebbre 2004

Mecca, I., *Metodologia e prove sperimentali per valutare la resistenza delle malte* in "Intervenire sul patrimonio edilizio: cultura e tecnica" a cura di F. Astrusa, C. Caldera, F. Polverino – Cedit, novembre 2006 Torino – ISBN 88-7661-718-3, pp. 735-744