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The Grange of S. Anna in Montauro: the Employment of a Particular Steel-Concrete Structure in a Borderline Case of Conservation and Restoration for High Seismic Area

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Abstract For at least five hundred years, the majestic grange of St. Anne in Montauro (CZ) has been overlooking the wonderful gulf of Squillace, placed at the core of Calabrian Ionic Coast. Masonry ramparts size (more than 7 metres high and 1,60 wide at the basis) together with the massive presence of four angular towers immediately hit even an inattentive beholder. Unfortunately, the predominant presence of grange results damaged by a clearly visible crack outline, which turned a great part of surrounding wall into a perpendicular heap of huge masonry portions. They appear disconnected and sheer, so that some panel systems are already collapsed on the north-east side of the building, included many internal constructions such as the church. The serious damage is not only due to repeated seismic events of high magnitude, that systematically run over this zone of Calabria. This article will describe in detail the methodologies and techniques of its making safe, considering the seismic and geological risk of the zone.

Keywords: Conditioned fruition, phenomenon of weatherin, maintaining the same building site

Introduction

The Grange, a term derived from the French *Granche*, represents, today, one of the historical structures for rural architectural tied to the agricultural activity of the surrounding area. In fact, *granche* means *barn*, indicating a structure employed for the conservation of wheat and seeds; but it can also have another meaning as housing estate of an ancient farm.

In particular, the monumental Grange of St. Anne is placed on a hill stretching out into the sea, at 425 metres above sea level, in a strategic position which dominates and controls the whole expanse of water in front of it; that it's also the best place for organizing and structuring the whole rural landscape. Erected in the core of Catanzaro's surroundings which cover the lands of Montauro in Calabria, it is part of a wider architectural housing estate dated back to Norman period and built up by Chartusians.

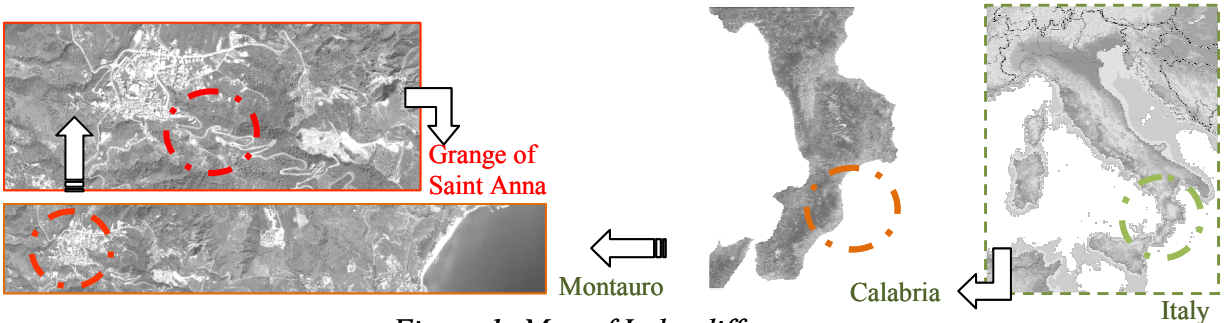


Figure 1: Map of Italy: different zoom

In 1000, the Normans regained the whole southern Italy, rescuing it from Byzantines, Arabs and Longobards and putting it in the hands of monastic orders, that *latinized* whole regions through donations and privileges. Bruno of Colonia received from the Earl Ruggero of Altavilla some lands situated in the Serre Calabresi (greenhouses), in St. Mary of Tower, the nucleus of the future

Charthusian monastery of Serra St.Bruno, that after few years will be enriched by the rural homes of Aurunco, now Montepaone and then Montauro, Oliviano and Gasperina.

Between the end of XI and the beginning of the XII century, in Montauro was built up a Grange in honour of St. James. During Medieval Age, the different monastic orders who alternatively followed one after the other in the direction of productive activity, extend their power in the southern-centre part of the italic peninsula, by including in their estates whole sides, marine terraces, hill zones, valleys, strategically displacing fortified garrisons of rural nature, suitable for creating little centres of power and control of all agricultural activities of the land. It's quite useful to mention a passage taken from Lekai, in order to give an empiric parameter that quantitatively could give an idea of how granges were planned and got into proportion:

"[...] Le dimensioni di ogni grangia corrispondevano alle circostanze locali e all'utilizzazione cui erano destinate. Quando si trattava di terreno fertile . [...], situato in pianura, una grangia poteva estendersi per molto meno di 500 acri. [...]" (L.J. Lekai I Cistercensi. Ideali e realtà, 1989)

The Grange of St. Anne: History and Analysis

The Grange of St. James in Montauro was planned by the Carthusian monk Lanuino. In 1193, all estates were given to the Cistercian order with a consequent change of dedication in favour of St. Jacopo and St. Anne. In the XIV-XV centuries, the information about Grange was quite insufficient. In 1513, the Carthusians regained its control, and the building was probably restructured and provided with an imposing fortified enclosure. At the beginning of the XVI century, the Grange was composed by St. Anne's Church, a "palace" and some annexed buildings. It included the surrounding lands, up to the coast, managed with different kinds of contracts, the houses and the total spiritual jurisdiction of churches by means of sums of money, called *decime*.

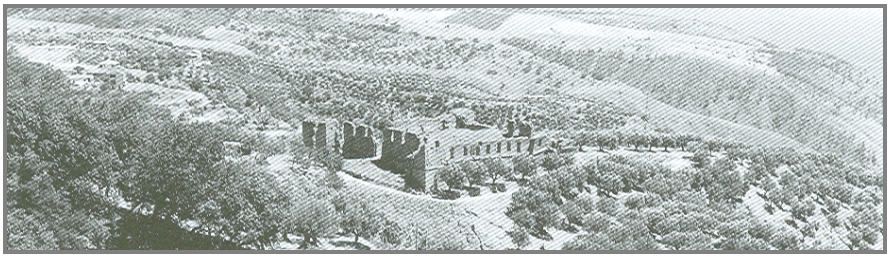


Figure 2: Grange of St. Anne in Montauro and its land, photo.

From the second half of the XVI century, probably for the increasing attacks of Saracens in the whole vice-reign, reduced to a distant peripheral of the great united empire of Charles V; the monks started up the *monumentality* of the structures in the land, with big restoration's works and the embellishment of the most important sacred buildings, with the creation of further management structures such as lodges for the manufacture and the conservation of raw materials. So, it is in this period that the term grange takes on the present historical meaning of organizational structure of the Charthusian monastery (Certosa), with the task of providing foodstuffs, above all wheat, for the monks. However, the monumentality is only an esthetical ostentation that hides a deeper revisit of the whole plan in order to adapt the rectangular enclosure and the four angular towers to the new defensive exigencies. In the first half of the XVII century, in spite of the East-West orientation, with west access and loopholes situated on the long sides and on the east short one, the Saracens regained the land. During this period, the Charthusians didn't submitted to them; trying to readapt the grange's plan and to recover the agricultural activity of the land. In 1783, a terrible earthquake devastated the whole region, provoking about 30.000 victims and the destruction of great part of the architectural and monumental heritage of southern Calabria. In particular, the Grange of St. Anne suffered a lot of damages:

"in tal tremuoto del 5 e 7 febbraio, nonché 28 marzo si rovinarono tanto la Grancia di S.Anna che il Cece, come pure la Chiesa di [...]" (Provicario d.Matteo Madonna, descrizione del 1791)

The Grange was declared unfit for use and, with the institution of the *Sacred Fund*, it was confiscated with other damaged goods, becoming a government property. A view of the structure dated back to the XVIII century can be caught in the wall paintings of St. Pantalone's Church in Montauro, where is depicted the procession of 1753 for the arrival of the Saint martyr's relics in Naples, that can give us an idea of the real structure's dimensions.

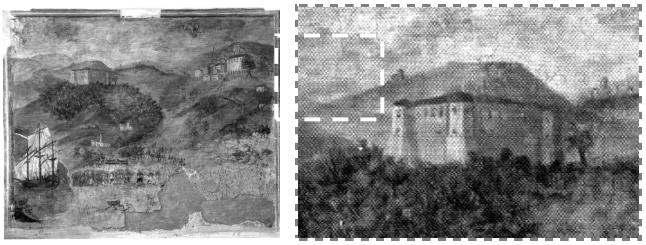


Figure 3: Grange of St. Anne painting, St. Pantaleone's church –Montauro

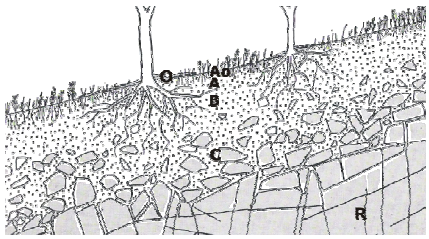


Figure 4: Formation of a detrital cover on the rock

The Land of Montauro, the Serre Calabresi and the Geological Ruin

Rocks' disintegration Rocks' *physical decay* is mainly due to the thermic variations, which develop in dissimilar ways according to different climatic areas, or different paedogenesis; occurring in the lapse of time between night and day. In special climatic conditions, the thermic excursion allows the freezing and fusion of meteoric waters, causing steady stuff's dilatations and contractions.

When these variations reach values of about ten degrees centigrade, they can cause many disintegrating phenomena, called: thermoclastisms and cryoclastism. The latter is attenuated by vegetal cover or cover of detritus, which determine a kind of protection for the rock below.

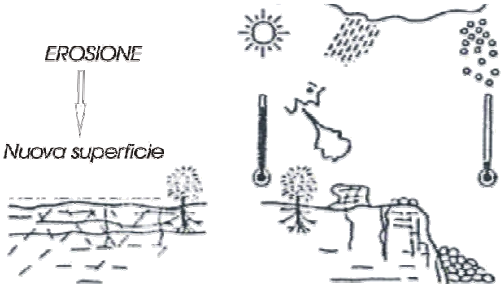
Each climatic geomorphologic process is symptomatic of a variation that pushes the temperate areas towards a gradual desertification together with irregular and intense raining phenomena, that cause a consequent disruption of land dynamics and possible landslides; so we can observe the same kinematic mechanisms in dissimilar lands. Calabria is one of the Italian region at landslide risk.

The Case of Calabrian Region The geological nature and the rapid climatic changes of great part of the Calabrian territory determines vulnerability and frailty; with phenomena of instability localized in metamorphic and plutonic lithotypes' concentrations, with a sequence of different levels of alteration in correspondence of these concentrations. The Calabrian clime is classifiable as hot temperate with dry summer (Cbs, sensu Koppen, 1936). However, in comparison with southern Italy, it presents some anomalies: the meteorological phenomena are modified by the peculiar physical structure of the land, where slopes' inclination is in contrast with the level areas, emphasizing its climatic oppositions. The whole region can be divided into two climatic areas: Tyrrhenian and Ionic. In particular, Sila's mountains and Serre, because of their position, are subjected to both little/violent and long/less intense downpours.

Therefore, almost all streams present a strong hydrometric variation, with consequent phenomena of deformation and alteration of the rocks below. Considering slopes' high inclination, faults' presence and discriminating factors, such as weathering intensity, and the related breaking systems; these altered outlines stir because of the effect of gravitational forces, generating different phenomena according to their own climatic condition, such as debris-flow, soil-slip, block-slide, etc.

The Phenomenon of Weathering In literature, rocks' alteration is a well-known phenomenon. At the beginning of the XX century, the first observations on this subject appeared, and in the eighties and nineties of the last century they were of great importance for the following studies, which define the relations between weathering and debris-flows landslides. Indeed, the straight correlation between rocks' alteration level and slopes' stability is an ascertained theoretical concept. The term *weathering* generally indicates a change of rocks' physical and chemical properties due to exogenous agents. Rocks' decay, proceeding from outside to inside, determines the formation of a quite thick alteration's

layer, that can be removed by erosion. When the rock of new formation is exposed to exogenous agents, it appears expanded in a pattern of cracks due to weight's reduction and to a physical and chemical change of its structure. So, the weathering is the result of the joined action of physical and chemical processes.



Actions:
Temperature variation;
Variation among dampness and dryness;
Cold and thaw cycle;
Roots action;
Wind and rain;
Crystallization;
Expansion.

Effect:
Stress;
Joints making Incipient cracks;
Rocks and between granules' disintegration.

Figure 5: Processi di weathering fisico

The first ones are considered phenomena of crumbling, such as: breaking, exfoliation, cryoclastism, aloclastism, which determine physical changes of the rocks. While the second ones cause chemical processes of alteration, that include oxidation, reduction, solution, carbonation, corrosion, hydrolyse and hydration, operating on rock's mineralogical equilibrium and determining its decomposition.

The latter can occur with different levels of intensity according to the rock's characteristics, the exposition and relief's inclination. Therefore, the decay's layers are the mechanical and petographycal result of the combination of old and new environmental factors. In the cluster scale, among the effects of weathering we can distinguish:

- the formation of joints and breakings or the possible widening of those in existence;
- the slopes' instability.

The Case of the Monumental Grange of St. Anne in Montauro (Cz)

The Condition of Places The Grange of St. Anne is on the top of a spur, in an intermediate position between Montauro and Gasperina, at about 400 metres above sea level, in a hill zone with a sequence of tablelands overlooking a coastal plain, broken up by the south hills of the ancient Soverato. The building has a wide enclosure with rectangular plan, the access on the west inner side, and loopholes and windows situated on all sides. We can immediately notice the existence of important stability's problems of perimetric masonries, which present vertical cracks, with steady crack anti-node and horizontal and transversal components of vectors, that can also be 30 cm. wide. This complex crack outline gets worse for localized overturning of instable masonry portions, which lack transversal monolithic nature, supporting overturning beyond level land. However, the masonry typologies are well-built up; the ashlars in rough-hewed stones are of medium size with some elements of big dimension strategically placed on the strip and the tip, with particular attention to toothings in masonries, junctions and angle irons. The ceilings are frequent and the thick joints of mortar are adequately crammed, with bricks that assure a good monolithic nature of the strip elements and of the transversal gear elements. Although masonry parameters are damaged, they result well-organised with a good transversal and longitudinal monolithic nature. Because of their construction, the elements result kinematized in monolithic blocks without local collapses and/or combined compressive and bending stress phenomena for the structural lack of face, and with cracks situated in direction of evident breakings of foundation lands. Moreover, the four angular towers show rotation and translation movements toward the outside, that don't concern masonry crosses. The foundation soil is clearly altered, with formation of joints and breakings both in the rock of new formation and in the detrital cover (decay's layer) mainly due to weathering effects.

Figure 6: Grange of Saint'Anna, photo

The First Intervention In 2008, there was a first intervention of conservative restoration and static consolidation on the Grange, with a first phase of verification of the evident stability's problems of masonries and foundation soil; and a second phase of plan of consolidation's interventions. They foresaw the perimetric masonries chaining and the relief's remodelling in the areas surrounding the towers. The first one was carried out through the use of a double layer of Cor Ten steel, which run along the whole perimeter and the angular towers. For the foundation land of the angular towers, hydraulic mortar injections were employed, with a low pressure in the discharge area of these structures, at least ten metres deep, and with tie-rod piles and micro-piles in the outside perimetric area of the towers.



Figures 7-9: Grange of Saint'Anna, First recovering, photo

The last part of the intervention concerned just one of the four angular towers, because it had an excessive impact and didn't respect the reversibility canons of conservative restoration. Moreover, thanks to the greater accuracy reached in further investigations, it was noticed the inaccuracy of the results of previous geo-electrical and tomographic investigations. Their improvement was due to the modern techniques of restoration that allowed the interpretation of rock's alteration phenomenon, caused by the crumbly action of weathering phenomena. So, on the basis of this information, it was planned a variation with a different proposal of intervention.

The Second Intervention The choice of optimizing the structural restoration's intervention of the Grange in St. Anne in Montauro (CZ), is due to the improvement of restitution techniques of geoelettrical tomographic investigations. The recent optimization of data acquisition allows to attain precise information on the global conformation of earth-like clusters situated under these geological sites. Both old and new geological knowledge converge in the choices concerning the actual variation, that can be summed up as follows.

Conversion of the foreseen stringcourse in c.c.a. at the basis of all masonries, another one positioned in the same way, built up by means of a mix of reticular girder in inoxidizable steel and blocks, in order to obtain an effective "belt" at the basis of our monumental building. This solution is disconnected from the perimetrical masonries, while it is connected to the garrison structures in the angular areas, where the towers are situated. In this way, the intervention results totally reversible in all its elements, while the belt is endowed with a sophisticated monitoring system, that inform of the macroscopic deformations' evolution of geological nature. This dispositive allows to carry into effect a kind of structural fuse, that is an inevitable element, considering the situation of geological degrade of this zone. It is necessary to take note of the instability's phenomenon of the place, known in literature as granites' weathering with devastating effects on the remaining masonries of the Grange.

Since at the present state it is not possible to oppose to this degrade, in order to protect the abovementioned architectural estate, it is necessary to affirm the principle of conditioned fruition of the building. However, with an adequate monitoring system, there will be a constant information

about the tensional state's evolution in the planned belt; while the fruition for the public will be temporary suspended when the prearranged conditions of effort will be reached.

The aim is of allowing the substitution of the structural fuse, with favourable modalities for its replacement, together with a new verification of the general structural conditions by means of the monitoring system, in order to carry out a seismic improvement of the whole building system.

Moreover, with special pull systems, a part of the evident masonry overhang will be recovered, considering that it concerns also some towers and the masonry panels of the boundary wall; so reaching a configuration with sufficient margins of safety in case of seismic actions.

The reduction system of walls/towers' *fuori piombo* will be carried out in sequential way; that is to say that firstly the less inclined wall will be straightened, then the adjacent one and finally the remaining part. The system will straighten not raise the walls, in order to guarantee the structures' safety. For the straightening of the three septa will be employed mechanic screw systems and not hydraulic ones, because the first ones are longer pull systems. In the pulling operation of the masonry septa will be favoured the stroke not the strength, even if the latter will be monitored. The inclination of septa will be monitored by employing 10 inclinometers. In order to carry out the protection works necessary to stem the uncontrolled waters' pouring in the land – a foundation exposed to the risk of landslide and to the atmospheric agents, in both south-west tower and other masonry sectors, by following the guide lines for the Protection of the Monumental Estate, established by the Ministry of Cultural Estates, we have carried out the verification of the masonries in elevation, revealing the need of masonry panels of more than 7 meters, and of dam elements (each 4 meters in the plan), completely hidden in the upriver side, which coincide with the inner side, while on the opposite one is foreseen the apposition of a metallic bolted and-plate of shaped bolt. It will be added a widening work of the bottom level, only in the perimeter of the north-west tower, because of the compressibility of the soil, due to more than 2 meters of clayey seam, sensible to the variation of water in the subsoil, and so subjected to incremental failures.

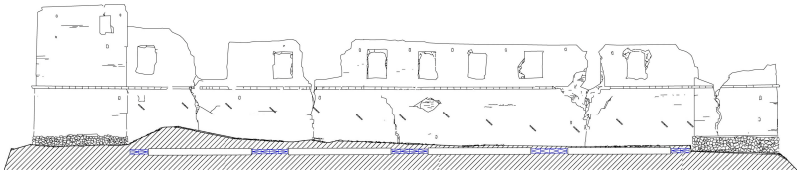


Figure 10: Grange of Saint'Anna, second recovering, draw

Conclusion: A Conditioned Fruition

In the preceding paragraphs, in addition to the description of a particular phenomenon of irreversible structural instability, concerning an important monumental building, has been described an intervention's strategy that allows a conditioned fruition of the Grange. It is important for us to divulge this concept that, in such cases, results the only one applicable in the field of structural restoration, maintaining the same building site.

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