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Survey and Project Design: an interdisciplinary model for post-earthquake recostruction in minor historical centers.

Rilievo e progetto: un modello interdisciplinare per la ricostruzione post-sisma nei centri storici minori

Post-earthquake reconstruction is a sadly recurring theme in Italy in the last 15 years, and the amount of people, monuments, administrations, technicians and economies involved make it a central theme for all sciences dealing with the anthropic environment.
The article witnesses a part of a more extensive research conducted by integrating different knowledge and in fact constituting a unitary technical-scientific chain which, from the survey of some historical centers, has led to the proposal of urban and architectural projects. Particularly here is shown the work done for Montebello di Bertona, in the province of Pescara, inserted in the crater of the earthquake of April 2009 and wants to propose an interdisciplinary model useful in every building process but particularly efficient in the case of post- earthquake recostruction.

La ricostruzione post-sisma è un tema tristemente ricorrente in Italia negli ultimi 15 anni, e le quantità di persone, monumenti, amministrazioni, tecnici ed economie interessate lo rendono un tema centrale per tutte le scienze che si occupano dell'ambiente antropizzato.
L'articolo testimonia una parte di una più estesa ricerca condotta integrando saperi differenti e costituendo di fatto una filiera tencico-scientifica unitaria che dal rilievo di alcuni centri storici ha portato alla proposta di progetti urbani e alla scala architettonica. In particolare qui si testimonia il lavoro svolto per il comune di Montebello di Bertona, in provincia di Pescara, inserito nel cratere del sisma dell'aprile 2009, e vuole proporre un modello interdisciplinare utile in ogni processo edilizio ma particolarmente efficace nel caso della ricostruzione post-sisma.

Keywords: Integrated survey, minor historical centers, post-earthquake recostrution, differentials critical project.

***Parole chiave**: Rilievo integrato, centri storici minori, ricostruzione post-sisma, progetto critico-differenziale.*

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INTRODUCTION

Technical-scientific specialism can be a double-cutting weapon: it can be a potential for development new Knowledge, but also a limit, a methodological and epistemological fence in which to lose sight of the goals, the "horizons" of research. Integrated multi-disciplinary action, or multidisciplinary research, seems to be the only possible choice to maximize the contributions of every part in the game: it is clear to everyone that proper interdisciplinarity allows better results by analyzing operations of each single contribution.
Post-earthquake reconstruction is certainly one of the application areas where each actor is led to make the most of well-structured coordination, enabling the integration of knowledge of different origin.
The research that is presented, not strictly recent but of a paradigmatic methodological value, is an integrated process that starts from the post-earthquake recognition and passes through a complete multimodal survey campaign, approaches a complex pilot project with further project planning to the definition of a preliminary project as per current legislation. In particular, the particular event is that the research team has been mandated to survey all the historic centers involved in the research and to coordinate the Reconstruction Plans and Pilot Projects for two specific case studies.
The case study presented in this article is the survey and the pilot project for Montebello di Bertona, in the province of Pescara, town in the crater of the earthquake of L'Aquila of 2009 and which along with other six centers has been affected by a research carried out by Architecture Faculty of Pescara between 2011 and 2012, whose outcomes are partially edited and whose credits are referred to in the note.
The main result obtained is the development of a wide-ranging methodological complex that involved multiple professionalisms ranging from direct and indirect survey to three-dimensional modeling, from architectural, urban and strategic planning, and controlling maintenance processes to legal skills for the preparation of the Reconstruction Plans, in a virtuous circle of paradigmatic value.

1. PROLOGUE

The price of human lives paid by the center of Italy to the series of earthquakes in the last 15 years is certainly a dramatic one, especially considering that this number could be adequately reduced or minimized by appropriate prevention policies, but the devastation suffered by the multitude of historical centers that make up the anthropic fabric of the central Apennine is, if not dramatic, surely more durable. For opposite reasons, the historic center of L'Aquila and that of the constellation of small historical centers affected by earthquakes in this historic juncture, risk seeing the local communities that kept them alive. And if the historic center of L'Aquila, demographically and quantitatively, as well as quality, historical-artistic artifacts, is a centerpiece of political and economic dynamics that slowly seems to revive the socio-economic tissue that until 2009 was in the smaller centers are likely to experience the earthquake as a definitive blow to the already shaky demographic balance: whole agglomerated buildings, sometimes even in the presence of sporadic architectural qualities, were already ahead of the earthquake in demographic decline, mainly for economic reasons, But now that they require not only economic efforts to restart communities already in crisis, there are not a few questions.
The key question we need to ask is: we can reconstruct these historic centers by rejecting the anachronistic slogan of "where was it and how was it", but keeping in balance the instances of restarting socio-economic dynamics and respect for the historical tissue and the traditional building?
We cannot match a unique solution, whether metho-

Fig.1. Celebrative stamps for recostruction of Bon's Tower in Venice, Event for which was coniated the motto "how it was where it was"

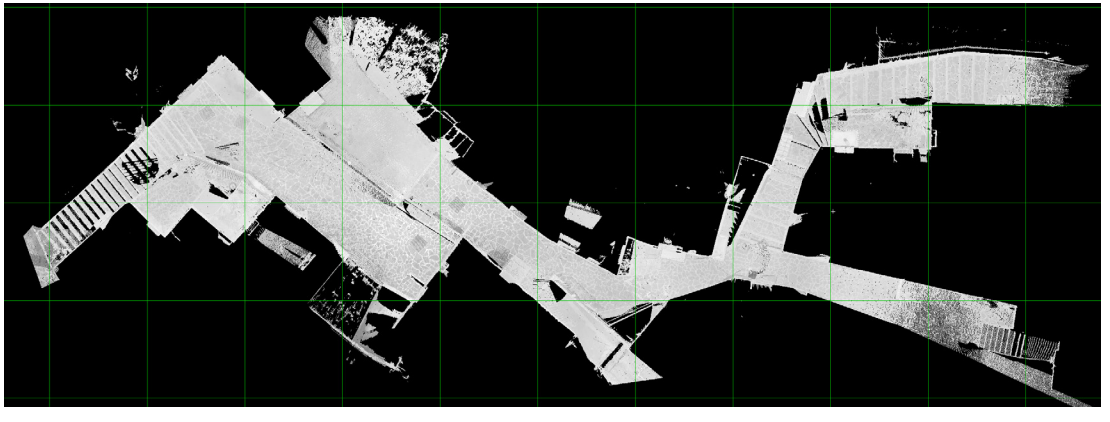
Fig.2. Planimetric view of a cloud of points resulting from the stiching of 10 shooting stations.

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dologically complex or ethically unattainable. Competing components to form an unlikely starting requirement are quantities and entities that make each application a case in itself. In particular, as anticipated, the fragmentation of interventions in the case of the center of Italy is such that working conditions, as well as project work, are often prohibitive. The main risk, however, may be the fortune of populism that has long since grasped the ancient motto that wants to rebuild the condition before a calamitous event - an earthquake, a landslide, a collapse due to lack of concern - as a form of exorcism of the event itself. But if some of the monuments can still be justified, as is the Bon belltower for which it was coined at the start of twentieth century, how can you think of rebuilding "where was it and how was it" historical town of a small abandoned center, which at the peak of demographic expansion did not reach 1000 inhabitants and whose architectural emergencies are of little value?

The first point to tackle is the opportunity to make a doubt about the "was is it", given that geological sciences in recent time have made such advances as the geographic location of active or potentially dangerous faults is easily identifiable, and that many historic centers are located in critical contexts. The whole set of reflections that can be proposed on this aspect is certainly complex because it invades the fields of geology, urbanism, sociology, economics, but also psychology. And for this reason we can not go beyond the problem of delocalisation of smaller communities, even though it is believed that from the ethical point of view is one of the most important factors to be evaluated.

Fig.3. Partial photopane on the side of Palazzo Crescenzi. Notice the shadow areas, in this case ordinary, affecting the facade.

The architect's role, however, is predominant compared to other interested figures, if our reflection focuses on "what it was", that is, on the figurative, spatial and performative conformation of the building. Evidently the buildings damaged by the earthquake, both slightly and substantially, is too often inadequate from the technical point of view in the structural parts, but, equally obviously, the inadequacy of current standards is extendable to healthcare performance: often built buildings for subsequent addition or freely modified, with superfetation for toilet facilities or inadequate spaces and with bad termo-acoustics performance, unfortunately are almost all in smaller centers, and the question of how to reconstruct while maintaining the historical value of the built-up while guaranteeing current standards, is difficult to solve. The only certainty that if we do not propose for a relocation, it is necessary to identify the figurative and morphological characters to protect, to keep intact the landscaping value of the small villages affected by the earthquake, but within this work space it is necessary to adapt the project to current standards, with all that it involves in terms of private property protection and qualifying licenses even in the presence of surface increases. They are all designing attentions, however, that have their roots in survey, especially if understood as extended beyond the boundaries of the graphic-figurative survey and, in addition to this, developed as a set of field activities aimed at the critical knowledge of the artifact

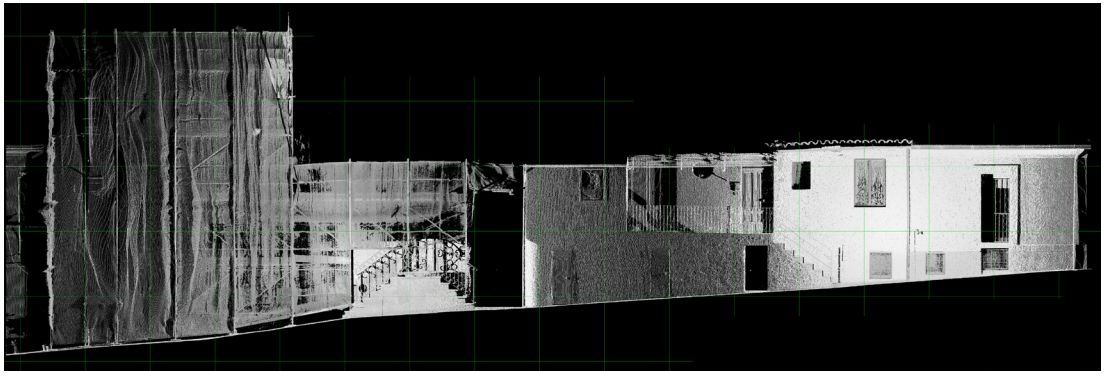

Fig.4. Photoplane showing one of the typical situations in which laser scanning is not effective: the presence of shipyards and, in particular, superstructures, both for safety and access to the yard.

2. THE INTEGRATED PROJECT: KNOWLEDGE, SURVEY, DESIGN[1].

Elaboration processes that are hermeneutically triggered at each design stage pass or derive from drawing processes. This is known since the centuries when the figure of the Architect took on a specific role in the process of creating and modifying artifacts or portions of cities. But the technical specialization required in the

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last few decades, as has already been anticipated, has put the design process, once a pseudo-artisanal process, into the hands of a group of different technicians and designers. This often entails a collapse of heterogeneous activities, such as the one of the survey and the project, which, on the other hand, have a closer relationship than the abstract techniques of digital representation can lead to thinking. The research that appears here, as already reported, has been a rare opportunity for make an integrated process management that has seen some researchers share responsibilities and operations both on important stages and on project phases. Specifically, this is the preparation of seven Reconstruction Plans, urban planning tools, but also economic ones, which regulate the procedures for the use of funds allocated but above all that govern the possibilities of building or urban planning in a very detailed way.

For the details of the research, refer to the publication of the results (Clementi, Di Venosa, 2012), however, which focuses mainly on the design proposals, while the author's research contribution is described below, with particular attention to the phase that the restitution of the survey, unpublished, led to the pilot project and its description.

The overall appeal for the seven historical center consisted in taken over 30,000 topographic points from nearly 500 stations, about 8,000 photographs, over 300 laser scanning stations, and numerous aerial photogrammetry shooting for a large amount of data to be organized particularly complex. The overall worklow was the following

:

1. Definition of the topographic topographic polygon with GPS consisting of at least four vertices connected to the points of the geodetic network;
2. Definition of the secondary topographic polygon with total station / GPS connected to the main;
3. Predisposition of photogrammetric and laser scanner target;
4. Photographic survey;
5. opographic Measurements of detail and support;
6. Surveying with point cloud acquisition (laser scanner);
7. Processing and organization of point clouds;
8. Semantization of point cloud;
9. modeling BIM;
10. Three-dimensional digital output.

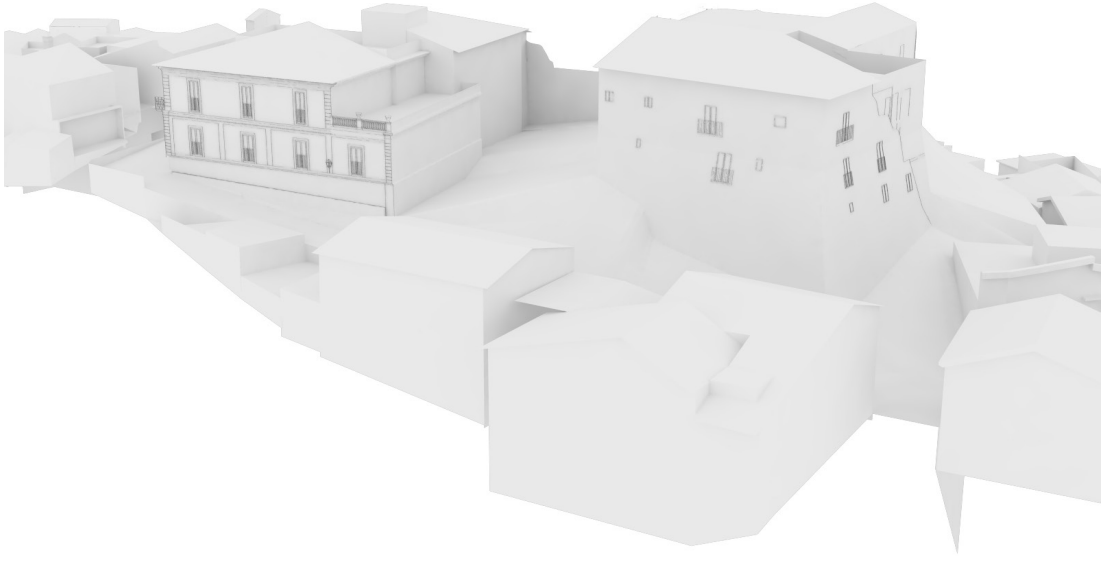

Fig.5. Image of the three-dimensional model on which the scale closing of the buildings affected by the Pilot project are evident: on the left Palazzo Crescenzi and on the right the Ducal Palace.

First of all, it should be specified that the instrumental survey, for particularly contingent timing reasons, were entrusted to an external team, coordinated in any case during the design and implementation of measurements and scans by academic staff.

The first phase involved the definition of the main topographical polygons that surround each single historical center with reference to perimeter areas, subject to specific detection; these operations are to be considered propedeutic to the georeferencing of the abited area and subsequent scans to be realized with Laser instrumentation. They were then initiated the definitions of secondary topographic polygon, internal to the abitated area that cross from side to side, performed to ensure the topographical coverage and the return of orographic situation of the historical centers in question. Same time were affixed to the target, the spot taken at this stage with topographic instruments, then hang up with 3d shooting laser scanner, aimed at georeferencing of the point cloud. These targets have been placed evenly in the area of the survey with particular attention to crossroads, squares, slams and, in general, public spaces.

Once the target set is physically and digitally as the basis for georeferencing, the laser scan campaign durated

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a few weeks.
In the first instance, point clouds, as can be seen in some of the images, have been elaborated both in matching and stitching, to produce cloud patterns of points resulting from different scans, all georeferenced by targets already mentioned.
These complex point cloud patterns (some have exceeded 20 million points) have been elaborated, organized and subdivided so as to have sub easily editable models, one per architectural unit (not always coinciding with a building or facade of a building). The urban scale and the post-earthquake condition of this extensive detection campaign have produced a large number of special cases to handle, from attempting to compensate for shadow areas due to elements other than occlusion to scanning due to scaffolding or centimeters safety.
Once the point clouds were handled in sub-models, are processed photoplanes sub-model by sub-model, agglomerate by agglomerate, were managed to recompose the building cues on the single street, both pedestrian and carriageways. In fact, even the term "photoplanes" fits this reality, because as in projective geometry a plan is understood (for example) as two-dimensional and straight support on which geometric elements are projected, in the application of our case the curtains are only occasionally revealed straight, while in all other cases (majority) are in varying conditions between the irregular and the curvilinear. Photopianes thus become the "developments" of the curtains, resulting from the sequential fitting of photopianes of individual parts, which are irregular and therefore chosen in relation to the actual morphology of the façade (pre-modeling semantics). Thus, non-Mongian views are obtained, albeit firmly anchored to the rules of projective geometry.
At this point, the work had to be enriched with a phase, compared to the previously hypothesized workflow, due to the complexity of the detected data. Then three-dimensional modeling did not come directly and exclusively with point clouds, but also through the realization of the two-dimensional representations of photopianes and curtains previously introduced. In this way, by interweaving the data from the celerimetric survey, precision increased (a maximum error of 1.5 cm was calculated), the possibility of errors in the interpretation of the point clouds substantially canceled, but above all the reduction of the times processing was such as to largely offset the timing of these further elaborations.
In this phase, as anticipated, a return was made through a careful and critical semantization of architectural elements for the remarkable buildings, all in BIM environments. Modeling, therefore, has been configured as a critical synthesis phase of the multitude of detected data and, with the intersection with other instrument tracking forms, such as the thermographic survey, or other forms of direct evidence (evaluation

Fig.6. General plan of interventions. 1. Car park for 30 places 2. Pedestrian Connection 3. 4. Cavea for multi-purpose area Multipurpose structures for sports and entertainment 5. Expansion of primary school with multi-purpose rooms 6. New flooring and design urban route 7. New Ground illumination 8. New Headquarters of the Civil Protection 9. New lookout-area of collection 10. Completion with modifications of the work on Palazzo Crescenzi 11. New link between Palazzo Crescenzi and Palazzo Ducale 12. New garden open to the public 13. Redevelopment with change of destination of the Ducal Palace.

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Fig.7. Plants and Prospects of the New Living Home Complex for Seniors. Note the differential approach, which reconstructed the traditional image of the Ducal Palace while still highlighting the distinction between the original wall and reconstructed wall. The details of the windows, finally, are ridden between a refused mimetism and an ostentation of the contrast of certain approaches to reuse.

of the state of maintenance of both the structures and the envelopes and the systems), it was possible to enrich the geometric-figurative database with useful data both during the economic evaluation phase of the interventions to be carried out in repairing or replacing the buildings damaged by the earthquake and in the subsequent maintenance phase for ordinary and extraordinary buildings

3. FROM SURVEY TO DESIGN

The pilot project was developed starting from the infograph compendium we have described, with a highly functional program that includes open space operations and artifact of a different type. The whole program is as follows:

sub-area 1. Restoration and partial reconstruction of a 16th century artifact. (Palazzo Ducale);
sub-area. 2.Reconnection of an artifact of the eighteenth century. (Palazzo Crescenzi).
sub-area. 3.Arranging a new Belvedere;
sub-area. 4.Demolition and reconstruction of a recent artifact (ex-slaughterhouse);
sub-area. 5.Project of a lifts from the arrival area to the city and the main square;
sub-area. 6.Project of road links between the parts of the Pilot Project.

For a reflection on the use of architectural technologies and languages, it opted for a critically-differentiated approach. Priority was given to an "environmental" relationship between the design choices - both of reuse and restoration or new construction action - and the pre-existing ones, clearly recognizing the landscape value that these smaller center have in a hilly area such as our interest: not emergencies of high historical architectural value, but overall urban entities often partially tampered with in the post-war period but still retain their semantic unitary character.

Sub-area 1 concerns the former Ducal Palace. The palace, often referred to as the "Castle", is a private property with remarkable historical and artistic significance. It is characterized by a prestigious position on the entire city center and is intended for residential use. It is a building originally built on a pre-existent fortified structure dating back to the domain of Duchess Mar-

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gherita d'Austria (1539-1586). Today, a large part of this building lacks a large part, in particular that which constituted the southern corner, which had collapsed for a long time (though after 1962, regardless of the last seismic event). The building is characterized by an irregular structure that denies its very ancient origin but also the shortage of a unitary project. It has a tiled basement and a larger ground floor, also partially turned, connected by a series of stairs leading to the upper floors: in addition to a small mezzanine on the first and second floor. Everything is covered by a roofing system.
The Ducal Palace was rated in class E, unmistakable building. The cracking panels, in addition to the actual collapses, show injuries on the walls and on the vaults, detachments in the soles and other surrenders. As far as non-structural elements are concerned, all the types of damage identified by the Aedes schedule (plastering, plaster casts, cornice falls, damage to technical networks) are presented. But the major problem seems to be the geological nature of the instability of the rocky spur (the so-called "Pietra Grossa") under the southern side of the palace.

Sub-area 2 concerns the Palazzo Crescenzi. Formally owned, it had already been intended for a senior citizen's home. Featuring a rectangular system, it is fitted with a less regular factory body, which also includes a smaller corner of private property. The building axially develops on both sides of a corridor and has a ground floor and a first floor connected by a convenient staircase. A pair of lifts has been fitted, never mounted, the roof is made up of a roof system.
The subject of a refurbishment being completed at the time of the earthquake is a good quality factory which for both of these reasons did not suffer damage during the earthquake in 2009. The intended use, with its obvious effects of a social character, they can only lead us to confirm it.
The relatively small size and scales economies that could be implemented where a substantial expansion could be expected led us to propose, in agreement with the municipal administration, its functional fusion with the Ducal Palace. The complex of the two buildings is thus economically more attractive to the private investor, ranging from a capacity of 20 beds to

Fig.8. Plan of the new Belvedere. Local stone, lawns, urban furnishings and new lighting are the elements with which space has been optimized, both from a landscape perspective and from the point of view of urban security: the new space, more than doubled over the previous one, is now more safe to use as an emergency storage space.

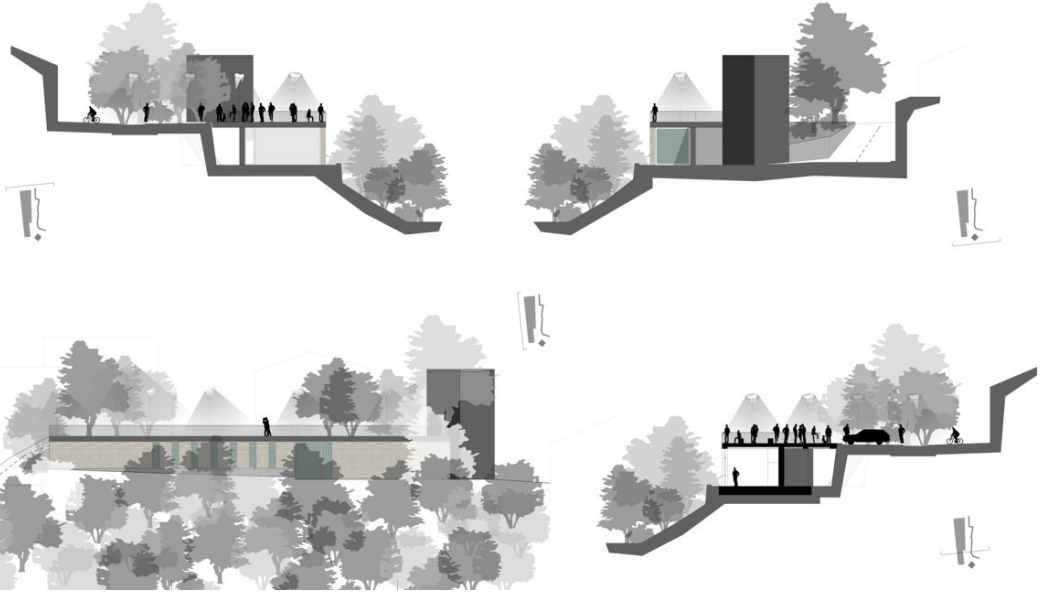

Fig.9a e 9b. Project sketches, prospects and sections of the new Civil Protection headquarters and the new Belvedere. Notice how the previous part of the parking lot was restored to the building to allow the extension of the useful area to the Belvedere.

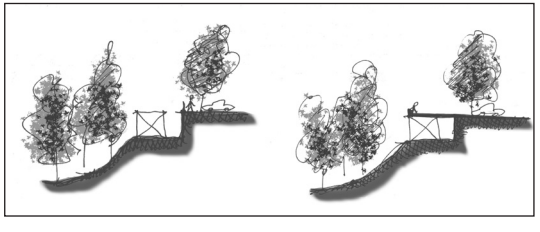

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Fig.10. Longitudinal and cross sections of the complex of the new home for the elderly stay. Note the tunnel of connection between the two structures, which, being unable to acquire one of the two architectural historical languages, disparages but respectfully.

Fig.11. Exterior view of the wall in the cribs of the new Civil Protection seat. The wall looks like a landscaping element to the macro-scale, making the ipogeo building really.

almost 50. Public intervention is also available in the availability of an experimental Telemedicine laboratory in the basement of the Palazzo Ducale, as agreed with the d'Annunzio University.

Sub-Areas 3 and 4, initially considered only nearly and integrated by project choices, concern the placement of the Belvedere, formerly a simple asphalt pavement used as a disorganized car park, and the demolition and reconstruction of the former slaughterhouse, a scarce artifact and heavily damaged by the earthquake, based on a lower level, just downstream of the containment wall on which the Belvedere insists.
The section of the Civic Protection Center in Montebello collects the volunteers of several neighboring municipalities, so it needs an adequate site, which has been identified with the new building resulting from the demolition and reconstruction of the former slaughterhouse.
The main project choice was the expansion of the Belvedere surface over the new building, making the latter substantially hypogeum. The Belvedere thus acquires a glimpse of the neutral landscape and mackerel with signs of anthropization, and the building also interprets the metaphor of a less vulnerable and therefore safer space.
The figurative choices are aimed at a substantial integration with the landscape, with regard to the main prospect of the new Civil Protection Headquarters with local stone gulls, and the lookout, with paving and local stone urban seating. The language, on the other hand, is deliberately abstract, away from the vernacular of wrought-iron lamps or porphyry-block pavements, because as with the other portions of the Pilot Project, it was preferred to opt instead of a recognizability autograph of the design gesture, a critical approach that adapts the design process to the contour conditions of the product

4. CRITICAL-DIFFERENTIAL APPROACH FOR EXISTING PROJECT

The design strategy is primarily aimed at upgrading the social and attractive tissue of the center, now deserted by the earthquake. For this purpose, the first planned intervention is a complete re-adaptation and adaptation of the access system to the historic center, both from the point of view of the carriage and the pedestrian. This redesigned accessibility connects with the

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road system that draws to the heart of the historic center, which brings with it not only the flows of people, but also the technological networks capable of ensuring that adaptation to the existing standards of existing real estate units. These open spaces are then connected and integrated with the architectural emergencies already cited, and with a large private garden between the two main structures, which is configured as a connecting element between the two buildings.
From a figurative point of view, the choices in the case of Palazzo Crescenzi were relegated to the chromatic arrangement, given the good condition of the building, while in the case of the Ducal Palace several solutions have been hypothesized, the definitive being of a critical attitude with regard to pre-existence: as it is possible to see from the design charts, the building has been restored keeping the differences between the wall edges of the different epochs with the reconstructed ones albeit visible, while ensuring a material and chromatic unitarity. With regard to the exterior facades, obviously the only detail that contemplates contemporary design is the windows, occasionally framed in white plaster. The coverage, which was almost completely collapsed after the earthquake, has been redesigned with the traditional technology of the place, with a main structure in wooden beams and circular section, secondary structure with square wooden beams and wooden or brick trunk covered by brick cladding. The definitive image of the building, prominent on the structure of the entire center of Montebello di Bertona, is an image that unequivocally invokes the traditional structure guaranteeing the preservation of a landscaped value as a whole, without however a totally mimetic approach which we believe is not adequate where transformability becomes so marked both by the size of the artifacts and the loss of large parts of the building due to numerous collapses due not only to the earthquake.
Inside, the many changes over the years have made the original distribution of the Ducal Palace unrecognizable. For this reason, and for the need to adapt to the new use, the whole particle redefinition was carried out, consolidating the walls and soles still agibile and building new partitions with light and reversible technologies. The most invasive adaptation, as it is easy to guess, concerns the plant design, but the need to ensure current housing standards is an indispensable objective.
In the interstitial space between the two buildings, as already mentioned, insists on a garden that will be arranged and in which a linkage between the two buildings is conceived, but it is proposed as a neutral element: a glass and metal gallery with matt cover a simple shielding system of the passive sun, which declares both its condition of contemporary manufacture and its non-originality to one of the two artifacts, amongst others linguistically very different from each other.
It's clear that in such a situation, architectural design projects, time constraints for drafting the project, huge volumes of data to be managed - not just due to Laser 3D scans - are both difficult to handle and a breakdown, the least, between the work of two different professions, risks creating a lot of problems in the design process. In this case, as already anticipated, the ability of a team to handle the survey in the preliminary architectural design has effectively optimized the entire workflow. In the case of Montebello di Bertona, for example, the architectural survey of the Ducal Palace, given the deep tampering of the original organism, due both to property alterations and to collapses not necessarily linked to the earthquake of 2009, was conducted by focusing on some elements - carriers and cracking framework - as it was clear and foreseeable a substantial change in the distribution system. While for the former slaughterhouse it was necessary to accurately identify the contour elements and the geological dimensions, given the demolition expected even after a simple survey. And so for the individual architectural elements, detected in detail in cases where the value of the single component was clear and coincidental, in cases where the purely documentary value was clear.
A process, ultimately, has allowed not only to optimize the survey work by precisely targeting the requirements of documentation and design, but also to foster the project process that by the relief inherited only the necessary information. A paradigmatic example of how the survey and project are actually interdependent, and how good a project cannot ignore a rigorous but at the same time critical survey

NOTES

[1] The process described below, as anticipated, is the result of a research conducted with a particularly articulated team that worked between 2011 and 2012 in the preparation of homogenous area reconstruction plans 5 in the Crater of L 'Aquila in 2009 for the municipalities of: Brittoli, Bussi sul Tirino, Civitella Casanova, Cugnoli, Montebello di Bertona, Popoli and Ofena. Below are the credits for the work done for the Municipality of Montebello di Bertona (Province of Pescara).
Client: Regione Abruzzo.
STM:
Gaetano Fontana.
Implementation Manager:
Marcellino Maria Chella.
RUP:
Angelo Melchiorre, Franco Visconti.
Scientific Director:
Alberto Clementi.
Responsible for Reconstruction Plan:
Valentina Carpitella (prima fase), Salvatore Colletti, Michela Giammarini.
Responsible for Pilot Project:
Livio Sacchi, Alessandro Luigini.
Responsible for Survey:
Livio Sacchi, Caterina Palestini e Giovanni Mataloni con Giovanni Caffio, Alessandro Luigini.

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