A RECONSTRUCTION PLAN FOR VILLA SANT’ANGELO AND TUSSILLO (AQ).
PRELIMINARY ANALYSES

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ABSTRACT

The historical centres of Villa Sant’Angelo and Tussillo have been heavily damaged by the 2009 Abruzzo earthquake. This paper presents the analytical work carried out in the two small towns, as the result of the first phase of their Reconstruction Plan. The initial work consisted in assessing the amount of debris obstructing roads and public spaces. Consequently, as an essential requirement for the subsequent reconstruction, a preliminary debris removal plan was formulated in order to ensure the public ways safety. On the basis of the careful examination of neighbouring walls connections, construction techniques and so on, the historical centres were divided into structural aggregates. Then, the 2010 and 2011 workshops surveys granted to define both the detailed buildings damage and pre-earthquake state. A closer analysis of each aggregate showed the local strengths and weaknesses in relation to the earthquake effects. Also, it highlighted the impact of widespread buildings negligence and incompatible strengthening techniques on their seismic behaviour. The collected data interpretation contributed to a Reconstruction Plan based on the core idea of conserving and enhancing the historical centres features and identity. This plan aims at defining intervention categories and guidelines for the reconstruction and at preserving the local buildings characteristics with measures and solutions integrated with the traditional building techniques.

Keywords: Historical construction, Reconstruction plan, Earthquake

1. INTRODUCTION

The preliminary studies on the town of Villa Sant’Angelo and his hamlet Tussillo was started in 2009 and consisted of the “Plan of debris removal and safety assurance”, along with a thorough analysis of the main historical centre damage state. Following an agreement between the University of Catania and the Town Administration, two seminars were held during the 2009/2010 Restoration Laboratory and the 2010/2011 Project 4 Laboratory of the Faculty of Architecture. The knowledge gathered during these experiences and the assiduous presence of the research staff, persuaded the Town Administration to propose a convention with the University of Catania, in order to ensure the necessary technical and scientific support to the Reconstruction Plan.

According to the normative framework [1] and to the guidelines of the Technical Mission Structure [2] – established to oversee the post-earthquake operations – the Reconstruction Plans coordinate the rebuilding actions undertaken by the public and private actors, with the following main purposes:

– defining the strategic guidelines in order to ensure a socio-economic recovery in the concerned areas;

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promoting the towns rehabilitation, in relation to density, quality and complementarity of local and public services on an urban scale, as well as to a more general environmental quality;
facilitating the displaced inhabitants return to the buildings damaged by the April 6th 2009 earthquake.
Thus, the Villa Sant’Angelo Reconstruction Plan regulates the town requalification and the urban texture harmonic re-establishment in the two centres of Villa Sant’Angelo and Tussillo affected by the 2009 earthquake. Particularly, it focuses on the restoration and reconstruction of the buildings and the urban historical identity and it is currently pending approval. This essay summarizes the studies and analyses on which its drawing up was based and anticipates some of its choices and operational guidelines.

2. POST-EARTHQUAKE DAMAGE SURVEY AND ANALYSIS

2.1. Damage state and emergency phase

The 2009 earthquake severely damaged the Villa Sant’Angelo built-up area and caused a death toll second only to that of Onna. The scenario after the April 6th mainshock was devastating: more than 60% of the Villa Sant’Angelo and Tussillo buildings – concentrated in the historical centres – had collapsed [3].

The emergency phase (since April to December 2009) was characterized by a widespread presence of debris, which made it difficult to access the central areas and even prevented from getting close to a considerable part of the buildings. However, the Town Administration promptly decided not to proceed to the rubble undifferentiated removal and to the demolition of the heavily damages buildings, in order to preserve the places memory and make use of the surviving elements for the reconstruction. According to this directive, a plan of debris removal and controlled demolitions was drawn up. It will be implemented without bulldozers and provides for a selection of the material which can be recovered from the ground strewn rubble or during the necessary dismantling operations [4].

The preliminary studies and the resulting plan have been marked by the awareness of the sites identity value and, consequently, by the measures aimed at their conservation. A careful analysis allowed illustrating each building collapses extension and, therefore, assessing the overall dimension of the affected urban texture. Moreover, this first phase focused on the examination of the different forms of damages, in order to ascertain the causes of such catastrophic effects on the historical urban texture.

2.2. Knowledge instruments and analysis procedures

The damage state induced to define various levels of study methodology – from urban to architectural scale – based on the survey of the existing conditions, as a fundamental knowledge instrument.

Immediately after the earthquake, the whole historical centre was analyzed and a 1:500 map was produced, bearing information about the wreckage amount and its location in the streets and squares, as well as the surviving walls conditions in terms of residual height. Therefore, the urban plan for safety assurance and debris removal was based on this knowledge. The plan aimed at warding off the dangers deriving from the damaged structures and at re-establishing the roads practicability, in order
to undertake the analyses on the damaged individual blocks and buildings and allow the technicians to proceed to the preliminary studies and to the consequent restoration or reconstruction projects (Fig. 1). The following step was the identification of the damage causes and, specifically, the evidently bad structural response of most of the buildings. For this purpose, in order to define generally applicable criteria for the safety assurance and the reconstruction activities, a selected a block was analysed as pilot study [5].

2.3. **Analysis of damage state of aggregates and public spaces**

The early studies carried out in Villa Sant’Angelo at urban and architectural levels allowed the development of a specific methodological approach for the analysis of towns suffering very strong damages. This work was then extended to Tussillo. This preliminary job, permitted to collect a deep knowledge consisting of a detailed study of all the blocks of the two historical centres (Fig. 2).

The different phases of the preliminary study, with the expected and achieved results are shortly resumed in the following.

![Fig. 2 Tussillo, Ground floor plan with masonry walls survey](image)

The first phase was dedicated to the retrieval and examination of the existing documents of the pre-earthquake state (maps, cadastral plans, photos).

The second phase was characterized by an intense inspection activity, consisting of the verification of the previously collected data and the gathering of those necessary to the restitution of the single blocks and public spaces architectural survey. The damage state was also analyzed by means of photographs and graphic schemes of structural elements, walls, horizontal structures, connections and anti-seismic systems.

The third phase consisted in the synthesis and subsequent interpretation of the collected material:

- for each aggregate, an axonometric schemes allowed the comparison between the state before and after the earthquake, in order to assess the damage and/or collapse mechanisms activated. As a result, we realized a system of correlations between damages, overall construction configuration (aggregate, evolution-transformation phases) and specific arrangements (building techniques);
- in relation to public spaces or network services (like electric, water, sewerage, gas and telephone mains), a series of thematic maps contain their configuration along with the damages detected.

2.3.1. **Damage state at aggregate-scale and pre-earthquake state restitution**

The first phase of the study involved the realization of a survey which would illustrate the aggregates post-earthquake state. According to the distinctive damage level of the single aggregates, different studying methods were applied. Thus, for the aggregates which resulted unfit for use, but had maintained their whole volume, a complete survey was carried out. Instead, the previous configuration of those which had partially or almost completely collapsed was reconstructed through the pre-earthquake cadastral and photographic documentation collected via Internet or provided by the inhabitants. The pre-earthquake state restitution was primarily aimed at identifying the collapsed and
unrecognizable volumes and, whenever possible, their vulnerability factors. In this respect, the first purpose had to improve the places knowledge (volumes, basements, heights and eaves lines of the buildings fronts) and the necessary correct attribution of property rights. Instead, the second one was important in order to conceive the damage causes and, consequently, define the technical guidelines for the reconstruction projects (Fig. 3).

2.3.2. Damage state of roads and public spaces
The analysis of the damages suffered by public spaces was particularly relevant while planning the reconstruction activities. The primary problems were related to the roads-blocking debris, to the bad conditions of pavements and road surfaces and to the inefficiency of all utility mains. Their damage assessment was essential as only the previous implementation of all the necessary infrastructures could allow starting the housing reconstruction.

As far as the pavements were concerned, it was found that the huge amount of debris in the public spaces had caused considerable damages. In addition, also the necessary interventions of debris removal and safety assurance, caused further deteriorations to the roads surfaces and their almost total impairment.

Furthermore, the state of abandonment of the last two years had favoured the rooting of weeds, thus increasing the damages. The services mains condition was more difficult to assess, but their overall obsolescence, the widespread failures and their inopportune placement on the buildings fronts suggests their replacement with underground systems. Moreover, the utility mains remake represents an opportunity to improve and enhance the whole historical centre.

2.4. Local building techniques and hypothesis about the damage causes
The comparison among the microzoning maps (level 1 and level 3) [6] and damage state allows some remarks on its causes. Generally, we find that the seismic hazard illustrated by the Homogeneous Microzones (level 1) does not appear to have significantly affected the damage distribution.

The old town of Villa Sant’Angelo, whereby most of the collapsed and damaged buildings are concentrated, is entirely located within a single homogeneous microzone with an uniform amplification
factor (equal to 1.2). However, the building structures response was very different, and different severity of damages was observed in adjacent buildings. This remark is even more evident for Tussillo. In this last case, the historical centre is located in a microzone classified as “stable”. On the contrary, the area of recent expansion, whereby little damages have been suffered, is placed in a microzone susceptible of a high amplification (equal to 2.7). Furthermore, the outline of a fault has been detected between the two parts of the town. Still, this fact does not seem to have affected the damages detected (Fig. 4). Therefore, both centres microzoning data do not show a relation between the distribution of damages and the different geomorphologic conditions.

The analyses conducted on the local construction techniques – and specifically on the masonry [7] – showed the variability in the quality of its textures and, on the other hand, a significant degree of weakening of the masonry structures (Fig. 5).

It can be assumed that the damages of buildings were mainly affected by their vulnerability, that is by factors related to the construction quality and to the weaknesses of the local techniques. Lastly, but most important, they derived from incongruous transformations resulting from recent alterations or advanced deterioration caused by lack of maintenance.

Fig. 5 Villa Sant’Angelo, Analysis of masonry textures, in order to assess their mechanical quality

2.5. Preliminary synthesis considerations and Reconstruction Plan criteria

The results of the illustrated investigations represented the basis for the following decisions. In particular, both the urban-scale study and the architectural-scale investigations constituted the basic material for the planning work. Thus, while the debris removal plan helped identifying and scheduling the following site works phases, the information on each aggregate and the damages interpretation supported the identification of appropriate intervention categories, tailored to these historical centres. Investigating the amount and the quality of the survived buildings also allowed the achievement of the awareness of masonry portions of good quality or of foundations elements that demonstrated a good resistance to the earthquake, which becomes important in the light of the conservative strategies. Another important aspect highlighted was the behaviour of replaced coverings and floors; in many cases it is possible to detect the harmful effects of interventions incompatible with the lower masonry. This detailed study identified the main characteristics to be maintained in the proposed reconstruction (such as profiles and heights of buildings, construction techniques and finishes). It followed the set of precise criteria and specific indications for interventions aimed at safeguarding the recognized values:

- the building texture and the aggregates were divided into Architectural Units representing the minimum intervention units defined by the Plan;
- the damage state detected in each Architectural Unit made it possible to identify specific categories of intervention, in order to avoid indiscriminate demolitions of masonry structures also partially survived to the earthquake;
- the mapping of vaulted basements found in most of the Architectural Units led to the plan choice of ruling out their total demolition, in order to safeguard this traditional architectural feature;
- based on photographic and architectural surveys of portals, windows, mouldings, outer stairs and so on, a catalogue of the local construction lexicon was issued, to which the technicians must accomplish for the enhancement of the elements existing in the relevant aggregates.
3. PURPOSES AND SETTING OF THE RECONSTRUCTION PLAN

The severity of the losses in the two historical centres of Villa Sant’Angelo e Tussillo required setting their reconstruction within an inter-scale approach. In fact, it was clear that all the urban plan prescriptions needed to be confirmed at the building-scale level, as well as each building-scale intervention affected the overall urban balance. In such a logic, every action belongs to a general project aimed at letting the urban texture and the landscape to recover from the devastating wounds inflicted by the earthquake.

Therefore, the Villa Sant’Angelo Reconstruction Plan adopted the basic criterion of the conservation of the historical texture and of the permanence of consolidated urban patterns. As the earthquake had already seriously reduced the built heritage, the plan aims at a stringent preservation of what survived and of the overall identity of the two historical centres (Fig. 6).

The Reconstruction Plans also serve as instruments in order to define the rebuilding costs of the towns affected by the earthquake. The definition of these costs must be based on the intervention category envisaged for each building, on the basis of its damage state.

However, according to its “planning” – rather than “programming” – scope, the Reconstruction Plan aims at governing the implementation of the planned interventions through guidelines defining the basic criteria for the reconstruction.

Fig. 6 Villa Sant’Angelo, Aggregates and Architectural Units damage condition

In particular, the measures envisaged by the plan concern a reconstruction to be carried out according to traditional building techniques, consistently with the identity of the local built environment. The plan is still being completed and its main purposes – both at the architectural and urban scale – are summarized below:

- the conservation and the increase of safety of the built heritage which survived the 2009 earthquake (see § 3.2);
- the promotion of a reconstruction compatible with the identity of the local built heritage (see § 3.2);
- the requalification of the urban context, in order to improve the life quality in the historical centres (see § 3.1);
- the enhancement of the two main squares as core civic spaces (see § 3.1);
- the reorganization of the system of roads, public spaces and strategic buildings for the seismic hazard prevention (see § 3.2).

3.1. The urban plan

The intervention on the public spaces system is addressed to the town requalification and to the improvement of its living conditions. The widespread collapse of crumbling or abandoned buildings gave the opportunity to propose punctual interventions of “demolition without reconstruction” within the urban texture. As a matter of fact, the creation of small squares must be seen as a re-establishment
of the inner courtyards system, which used to characterize the urban form of Villa Sant’Angelo, before their filling as a consequence of the following dense growth of the buildings. These “new small squares” are, indeed, comparable, for position and dimensions, with the existing courtyards which still partly characterise the historical centre.

Finally, a specific attention is paid to the arrangement of safe areas and escape ways. Interventions aimed at reducing the vulnerability of the buildings fronts will be carried out in the existing public spaces which can be eventually used as safe areas during the primary and secondary emergency phases. Similar measures are also envisaged for the pedestrian paths of the town centre, in order to provide the vaulted passages safety assurance, the pavements restoration and the placement of main directions signals towards the meeting points (Fig. 7a).

![Fig. 7 (a)Villa Sant’Angelo, urban restoration interventions and (b) intervention categories for the private buildings](Image)

3.2. Blocks and buildings intervention categories
The operational categories identified by the Reconstruction Plan as much as possible privilege the preservation, enhancement and recovery of the remains. For this purpose, the plan provides specific prescriptions concerning the methods of intervention and conservation of structures as well as finishing elements. In particular, the Reconstruction Plan establishes that remaining parts and elements of the pre-earthquake buildings must be normally preserved, restored and consolidated, so to form the basis for the renewed urban texture. The following intervention categories defined by the Reconstruction Plan must be applied according to the relevant national codes and regulations and to the seismic vulnerability mitigation studies.

**Strengthening:** The areas of strengthening are parts of the urban texture, which have been partially affected by the earthquake and can be reconstructed using all or part of the existing masonry structures.

**Completion:** The completion areas are parts of the urban texture, which have been deeply affected by the earthquake but have maintained their architectural, typological and structural consistency. For their relevance and position within the urban texture, they can be restored and completed. Part of the existing masonry structure can be reused and the reconstructed parts must be compatible with the original masonry construction system.

**Reconstruction:** The reconstruction areas are parts of the urban texture, which have been destroyed by the earthquake and whose architectural typological and structural consistency is definitively compromised. For their relevance and position within the urban texture, their alignment, placement and shape can be modified according to the urban-restoration prescriptions of the Plan. In the reconstruction areas, it is possible to use the masonry construction system.

**Demolition without reconstruction (with relocation of volumes):** For the purposes of the urban texture restoration and of the re-establishment of the inner courtyards system, the Reconstruction Plan identifies the areas to be demolished without reconstruction. The demolished volumes will be relocated in other urban areas according to the directives of the Villa Sant’Angelo town plan (Fig. 7b).

3.3. Seismic regulation and construction measures for the aggregates projects
Whenever interventions on existing buildings are needed in order to increase or restore their load carrying capacity, the Italian Technical Construction Codes envisage three different intervention categories, depending on the aimed safety level: (i) repair or local interventions, (ii) improvement, increasing the structural safety, even if not accomplishing with the stringent regulations required for new buildings, (iii) upgrading, achieving the safety standards prescribed for new buildings.
In addition, whenever the buildings are a part of aggregates, this regulation prescribes the identification of the structural units for the safety verifications.

The plan construction directives refer to the national technical codes, specifying them in consideration of the damage state of the urban texture. In order to facilitate the basic choices of the building reconstruction and the projecting activities, the Plan identifies a series of construction matters recurring in the different damage forms of the building texture; some of them are shortly listed below.

**Strengthening:** An architectural unit or a portion of the aggregate which need this kind of intervention show the necessity of a range of works from the cracks repairs to the improvement of the connections between the different elements (wall/wall; wall/roof; wall/floor). The purpose of this intervention is to improve the structural behaviour and may involve the elimination of original configuration deficiencies or of vulnerabilities deriving from incongruous transformations. This choice can be defined only after a careful analysis of the existing textures through the realization of a survey showing the section cross-connections.

**Completion:** The first issue concerning an architectural unit or a portion of aggregate which need this kind of intervention is that of the connection between the remaining walls and the portion to be reconstructed. It is preliminarily necessary to check the remaining structures, in order to assess the masonry quality and the need of further removal or strengthening works. Once the preliminary works are carried out, it will be necessary to adequately shape the collapse edges, so to accommodate the new masonry. The new walls shall have adequate thickness and shall be carefully tied to the existing masonry (realization of teething-stones at regular intervals).

**Restoration:** The main issue concerning an architectural unit or a portion of aggregate which need this kind of intervention is the choice of the construction technique. The Restoration Plan promotes the masonry technique with recycled and/or modern materials (Uni format bricks). The choice of rebuilding techniques other than masonry would present additional issues. For example, the necessary detachment from the adjacent architectural units compels to strengthen the originally common masonry structures which, after the interposition of an in-between space, have lost the previous constraint deriving from the adjacent structures.

## 4. CONCLUSIONS

The methodology adopted was based on the coordinated sequence of the different steps of knowledge, interpretation and planning. The detailed analysis of the damage scenario, of the materials and structural conditions and of the public spaces configuration represented the necessary knowledge basis for the subsequent reflections. This preliminary choice led to adequately study and analyze the towns characteristics, their qualities and main factors of vulnerability, in order to combine the conservation needs with the safety of residing population that will have to go back and live in the historical centre. The restitution drawings of the pre and post-earthquake conditions represented the first interpretive synthesis of the collected data. The subsequent considerations and hypotheses about the damage causes has been formulated on the basis of these preliminary analysis. Particularly, the comparison with the geological and seismic microzoning maps showed a cogent link between the damage level and the construction characteristics of the built heritage, the masonry quality, the buildings conservation state and the compatibility of their transformations over time.

The usefulness of such an information for the next planning phase is evident. On the basis of the preliminary analyses, we identified specific intervention categories, closely related to the buildings damage state and aimed at the precise definition of their possible transformations. The Reconstruction Plan combines the study of the built heritage identity features – to be conserved and enhanced – with the definition of intervention criteria in order to ensure, at the same time, the safety increase and the adoption of consistent and compatible solutions. Therefore, the seismic hazard mitigation should not be considered as a purpose conflicting with the conservation needs, but rather as an indispensable instrument for the survival of the built heritage and its recognized values.

## ACKNOWLEDGEMENTS

The authors thank for their contributions: arch. Francesco Andreani involved in the definition of the urban plan and the implementing technical rules; arch. Margherita Giuffrè for the analyses concerning the seismic vulnerability mitigation at the urban scale and the comparison between damage state and seismic microzoning; Prof. Bruno Messina (University of Catania) and arch. Ezio Siciliano who
contributed to the urban projects for the Villa Sant’Angelo squares; the young graduates Riccardo Accetta and Davide Gerbino who participated in the Tussillo historical centre’s analyses. Finally, they gratefully acknowledge the support of the inhabitants and the Town Administration of Villa Sant’Angelo.

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