CISBAT

# PROCEEDINGS VOL. I


## INTERNATIONAL CONFERENCE

FUTURE BUILDINGS & DISTRICTS

SUSTAINABILITY FROM NANO TO URBAN SCALE

**9 - 11 SEPTEMBER 2015 EPFL**

LAUSANNE - SWITZERLAND

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# CISBAT 2015

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International Scientific Conference
9-11 September 2015, EPFL, Lausanne, Switzerland

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FUTURE BUILDINGS & DISTRICTS –
SUSTAINABILITY FROM NANO TO URBAN SCALE


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# PREFACE

"Future Buildings and Districts – From Nano to Urban Scale" was the topic of the international scientific conference CISBAT 2015, which took place in the Swiss lakeside city of Lausanne from 9 to 11 September 2015.

Designed as a platform for interdisciplinary dialog and presentations of innovative research and development in the field of sustainability in the built environment, the conference covered a wide range of subjects from solar nanotechnologies to the simulation of buildings and urban districts.

CISBAT 2015 was the 13th edition of CISBAT, whose vocation is to present new perspectives offered by renewable energies in the built environment as well as the latest results of research and development in sustainable building technology, in a setting that encourages networking at the international level. The conference assembled building scientists, engineers, urban planners and building designers from all over the world in an effort to promote clean technologies for sustainable buildings and cities. Close to 170 scientific papers were presented during three intense days of conference.

CISBAT 2015 was organized in scientific partnership with the Massachusetts Institute of Technology (MIT) and Cambridge University. Furthermore, the organizing committee was proud to be able to count on an international team of renowned scientists to ensure the quality of presented papers. The conference also teamed up for the third time with the Swiss Chapter of the International Building Performance Simulation Association (IBPSA-CH) to strengthen the subject of “Building Simulation”, one of the conference's leading topics.

Finally we were proud to host an outreach event of the Swiss Competence Centre for Energy Research “Future Energy Efficient Buildings and Districts” (SCCER FEEB&D) as well as a Workshop on Grid-Supportive Buildings organised by Fraunhofer IBP and E.ON Energy Research Center, RWTH Aachen.

Organised under the auspices of the Swiss federal Office of Energy (SFOE) and the Federal Commission for Technology and Innovation (CTI), CISBAT 2015 connected researchers and projects and gave an exciting insight into current research and development in the field of sustainable buildings and cities. It is our greatest wish that the conference will have led to a better understanding of the issues at stake and to fruitful, creative collaboration between its participants.

Prof. Dr J.-L. Scartezzini

Chairman of CISBAT 2015
Head of Solar Energy and Building Physics Laboratory (LESO-PB), Swiss Federal Institute of Technology Lausanne (EPFL)

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# CATEGORIZATION OF THE HISTORIC ARCHITECTURE IN PALERMO FOR THE PURPOSE OF ENERGY ASSESSMENT

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## ABSTRACT

The strategies to improve the energy performance of historic buildings can be compatible with their conservation if they are referred to material, construction, distribution features, strictly related to a local level. In the EU project EFFESUS, a method of categorization has been developed for historic districts and tested on the Swedish town of Visby. This approach aims at defining a manageable number of representative buildings, or archetypes, through which the energy performances of the district constructions, and their potential improvement, can be analysed. The present paper applies this categorization method to a representative part of the historic centre of Palermo, regulated by the urban plan "P.P.E. Centro storico". The study aims at relating the existing building typologies, defined in this plan, to the characteristics influencing the energy performance of the historic architecture of the town. This analysis has resulted in twelve building categories, proposed to detail the district typologies. The categorization of the historic architecture of Palermo and its integration with the current typologies are meant to facilitate guidelines for the improvement of its energy performances: for each category, several refurbishment measures can be analysed regarding their compatibility to the conservation restrictions; at the same time, their effectiveness can be assessed on the basis of geometric, distribution and construction features of the buildings.

*Keywords: historic architecture, categorization, energy improvement, building typology*

## INTRODUCTION

The historic architecture is a relevant part of the European building stock. Therefore, its contribution to reduce the consumption of resources, notably energy, can be relevant in the construction sector. At the same time, the importance to preserve its material and aesthetic features highlights the risks related to an uncritical refurbishment, carried out through techniques now common, but suitable for modern constructions. For this reason, the Directive 2010/31/EU and the great part of its national implementations allow that officially protected buildings are exempted from minimum energy requirements. This decision excludes vernacular constructions, although their remarkable significance both as part of the landscape and as evidence of technical culture. On this subject, the scientific literature reports cases in which the energy efficiency of historic buildings has been improved in ways compatible neither to their conservation, nor to their hygrothermal function.

On the other side, there is a growing awareness of the question of energy use and indoor environmental quality in historic buildings, not only listed ones. Recent examples are the rating system *GBC Historic Buildings* and the *AICARR* Guidelines for the energy efficiency in historic buildings. Based on common conservation principles, these measures require an in-depth analysis of the building. Therefore, the reference to material, construction, typological features, strongly related to the local context, is necessary. From this point of view, in the European project EFFESUS [3, 5] a method of categorization has been developed to analyse

the energy performance and potential improvement of the building stock in historic districts. In the present paper, this method is applied to the heritage historic district of Palermo.

## STATE OF THE ART

Several research projects have aimed at developing guidelines for the energy efficiency of the building stock. To analyse their performance and the possibilities of its enhancement, some studies follow a typological approach. In the French project BATAN [2], "thermal typologies" are used to describe the historic architectural heritage according to the aggregation of buildings and their material and construction features. The EU project TABULA [6] has described the European building stock by means of typologies, referred to the building size and age of construction. For each group, average values of several parameters identify archetypes or representative architectures. Through the selected constructions, the energy performance and the potential improvement have been calculated for each typology. The project, however, focuses more on modern constructions. Regarding historic districts, recent projects [1, 4] propose the analysis and simulation of case studies on the base of quick *in situ* inspections, through which relevant data are collected (about materials, construction techniques and envelope components, building size and distribution).

The European project EFFESUS has developed a method to categorize historic districts, which has been applied to the Swedish town of Visby. The historic district is categorized with respect to building size and aggregation, to construction and distribution features, to the technical systems for heating and cooling. Besides these characteristics, the cultural significance of the architectures and the legislative restrictions of protection are taken into account. Starting from the CityGML data model, the categories are defined according to the number of storeys and adjoining walls, the ground floor area and the volume. Further subcategories can be defined considering data such as the envelope construction and the systems used. As in TABULA, for each category a representative, real building or an archetype is defined. Therefore, a manageable number of representative buildings allow for an in-depth analysis of energy performances and the potential improvement of the historic district [3].

## OBJECTIVE OF THE RESEARCH

The architectural heritage in the historic centre of Palermo is regulated by the urban plan "P.P.E. Centro storico" (1993), which is based on a typological approach. Its typologies are strictly related to the historical use of buildings: in the group "edifici speciali religiosi" the religious architectures (both convents and churches) are collected, in "edifici speciali civili" the public constructions (civilian and military), while the residential buildings are distributed in five typologies ("catoi semplici" and "catoi multipli" for the vernacular constructions, "palazzi" for aristocratic and monumental buildings, "palazzetti" and "palazzetti multifamiliari" for buildings reproducing the model of "palazzi" in a smaller size). Furthermore, for each typology the urban plan lists the elements to be preserved and the measures allowed, strictly connected to different conservation requirements. Hence, the categorization method developed in the EFFESUS project can be particularly useful in this context, where the aim is to relate the P.P.E. typologies to the features influencing the performances of the historic buildings, in order to integrate the energy improvement of the architectural heritage of Palermo with the conservation practices allowed by the urban plan. In order to limit the scope of the investigation, the following buildings are excluded: churches, constructions subsequent to the second world war (typology "Edilizia postbellica") and buildings not realised with traditional techniques.

## METHODOLOGY: SELECTION AND COLLECTION OF DATA

This research applies the EFFESUS categorization to "mandamento Castellammare", one of the four parts which the historic centre of Palermo is traditionally divided in, comprising more than five hundred buildings. The main data sources were the urban map on a scale of 1:500 ("Carta tecnica", 1981) and the graphic documents of P.P.E. (1993). Since several building restorations have been carried out in the last two decades, these maps have been compared to more recent aerial photographs (*Bing Maps*, *Google Earth*; 2014) and checked through *in situ* inspections in some cases. For each building, the collected data regard mainly geometric features, notably the ground floor area and perimeter, the volume and the number of storeys. Furthermore, the typology the P.P.E. attributes to the building has been considered; for a small area not included in the plan, it has been assigned by analogy. The heating and cooling systems employed are not taken into account, because of the difficulties to find homogeneous and certain information. The data have been collected through the software *QUANTUM GIS* on the georeferred vectorial map of the historic centre, and processed in *Microsoft Office Excel*.

The boundaries considered for each construction are those, which the urban plan reports for the building units. Just in few cases, the limits have been modified, if relevant discrepancies exist with the current building state. The ground floor areas have been calculated referring to these boundaries, including outdoor spaces if covered by closed ones. However, the building size is expressed in terms of volume, while the number of storeys is not manageable. The historical development of Palermo's historic centre is based on the raising of existing constructions; consequently, the same number of floors refers to constructions very different in size, while some buildings can be connoted by more than one number of storeys. On the other hand, the urban map ("Carta tecnica", 1:500) describes the geometry of all roofs with their absolute heights, so it allows calculating the construction volumes in detail. Hence, each building unit has been divided in polygons, representing simple roof geometries. The corresponding relative heights have been obtained by subtracting the ground level reported in the map. Finally, outdoor covered spaces have been subtracted in the volume calculation.

The number of adjoining walls is not relevant to represent the aggregation of buildings in the fabric of the historic centre of Palermo: almost all the architectures are parts of urban blocks, generally characterised by irregular shape; at the same time, the buildings have often complex geometries, since they result from the historical union or division of previous constructions. Moreover, relevant distribution features such as the courtyard are specific to some typologies, as pointed out in the P.P.E. In this paper, only one parameter is introduced to consider synthetically these characteristics. This term is the ratio between the ground floor perimeter shared with the adjoining constructions and the total, and includes the courtyard when present. For the sake of simplicity, it has been assumed that the shared perimeter is common to the adjoining units for all their vertical extent. This hypothesis is acceptable because of the quite homogeneous distribution of heights in the analysed building stock.

As mentioned above, the study takes also into account the typology attributed to each unit by the urban plan. This information is important to guide the data analysis and connect the categories to the P.P.E. typological structure. At the same time, especially the residential typologies point out features concerning the inner distribution of buildings, but not their construction characteristics: the great part of the architectural heritage of Palermo results from centuries of building activities, where similar materials and techniques were used both in the vernacular and monumental architectures. Therefore, some evident differences, related to structural, spatial and decorative solutions peculiar to imposing architectures, are implicitly expressed in the current typologies. However, a distinction based on the age or techniques of construction would be hard, but also not relevant for the purpose of this research.

## PROPOSAL OF CATEGORIZATION FOR THE HISTORIC ARCHITECTURE OF PALERMO

The categorization proposed in this study is based on the size of buildings, on their aggregation in the historic urban fabric and on the limits to intervention set by the urban plan. The thresholds for the aggregation and dimensional features have been defined by analysing the data of both each typology and the stock as a whole. The study does not aim at substituting the P.P.E. typologies, but at connecting them to the energy performance of the buildings. Nevertheless, starting from the existing typologies, the categorization would have resulted in a strong reliance on the characteristics of each group. The definition of common thresholds, on the opposite, leads to categories for which, given the geometric features, the strategies for energy improvement can be assessed on the base of different levels of protection.

Some relevant thresholds identify features specific to vernacular constructions. Concerning the aggregation, only "Catoi semplici" and "Catoi multipli" include buildings whose shared perimeter overcomes two thirds of the total: these constructions are generally in the middle of blocks and are not connected to inner courtyards. Moreover, the volume range for the vernacular buildings varies from 200 $m^3$ to 3500 $m^3$, while greater differences emerge in the other typologies: the volume ranges from 3500 $m^3$ and 40000 $m^3$ for the monumental residences, from 7000 $m^3$ and 80000 $m^3$ in the typology of convents and from 1000 $m^3$ to 10000 $m^3$ for "Palazzetti". Hence, a wide range marks notably the monumental buildings, whose peculiarities can not always be referred to typological characters. Two thresholds, consequently, have been identified for each of the analysed features. About the shared perimeter, the limit of two thirds (67%) is characteristic only to a part of the vernacular buildings; on the other side, a maximum value of 40% comprise the architectures, mainly monumental, where an inner courtyard is present. Considering the volume, the value of 3500 $m^3$ distinguishes both the vernacular buildings and the monumental ones, limiting the first at the top, the latter at the bottom. A second threshold, identified in the maximum volume of "palazzetti" (10000 $m^3$), has been introduced to highlight the buildings whose peculiarities overcome the typological features.

The seven groups of buildings defined through these thresholds have been subdivided according to the limits the urban plan sets to the intervention. For this purpose, three "levels of protection" have been introduced, referring to the distinction between "ristrutturazione" (renovation) and "restauro" (restoration). Derived from the national building regulations, this is the main difference among the measures allowed by the plan: restoration aims at preserving the architectural organism by respecting its aesthetic, typological and construction features; renovation allows a partial transformation of the building unit. Therefore, the possibility to substitute construction and technical elements and change the internal distribution of the space is higher in the latter than in the former. The urban plan for the historic centre of Palermo, while requires the restoration for the monumental buildings ("Palazzi", "Edifici speciali civili", "Edifici speciali religiosi"), allows renovation for the other typologies. However, a second specification has been considered necessary in this study: P.P.E. identifies indeed building elements to be preserved as characteristic to some typologies, so influencing the actual possibilities of refurbishment. Furthermore, although renovation is the way allowed for "Palazzetti", for some of these buildings and for many included in "Edilizia conseguente al piano regolatore Giarrusso" restoration is required. At the same time, also if subject to renovation, their formal and spatial features generally limit, compared to vernacular buildings, the possibilities of the intervention. Hence, while a level ("3") characterises the typologies for which restoration is required, two "levels of protection" are introduced when renovation is allowed: "level 1" for "Catoi semplici" and "Catoi multipli", "level 2" for "Palazzetti", "Palazzetti multifamiliari" and "Edilizia conseguente al piano regolatore Giarrusso".

Thereby, sixteen categories result from the seven groups based on geometric features. However, compared to the whole sample, four of them have been removed, since both the number of buildings and their total volume are less than 1% of the total. For each of the remaining twelve categories, the average values of ground floor area, volume and shared perimeter have been calculated, as reported in table 1. These values are meant to be used to identify representative buildings, or archetypes, through which the energy performance and the potential improvement of the architectural heritage of Palermo can be analysed.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Level 1** | **1.I**<br>Volume ≤ 3,500 m$^3$<br>Adjoining perimeter ≥ 67 % | | | **1.II**<br>Volume ≤ 3,500 m$^3$<br>Adjoining perimeter 40÷67 % | | | **1.III**<br>Volume ≤ 3500 m$^3$<br>Adjoining perimeter ≤ 40 % | | | |
| | **96** buildings | 17.3 % buildings<br>3.9 % volume | | **147** buildings | 26.5 % buildings<br>9.1 % volume | | **46** buildings | 8.3 % buildings<br>3.3 % volume | | |
| | Average values | 64 m$^2$<br>970 m$^3$<br>75.4 % | | Average values | 101 m$^2$<br>1,488 m$^3$<br>53.6 % | | Average values | 120 m$^2$<br>1,710 m$^3$<br>28.5 % | | |
| **Level 2** | **2.I**<br>Vol. ≤ 3,500 m$^3$<br>Adj. per. 40÷67 % | | **2.II**<br>Vol. ≤ 3,500 m$^3$<br>Adj. per. ≤ 40 % | | **2.III**<br>Vol. 3,500÷10,000 m$^3$<br>Adj. per. 40÷67 % | | **2.IV**<br>Vol. 3,500÷10,000 m$^3$<br>Adj. per. ≤ 40 % | | **2.V**<br>Vol. ≥ 10,000 m$^3$<br>Adj. per. ≤ 40 % | |
| | **35** | 6.3 % buil.<br>3.0 % vol. | **41** | 7.4 % buil.<br>4.2 % vol. | **29** | 5.2 % buil.<br>5.8 % vol. | **43** | 7.8 % buil.<br>9.4 % vol. | **10** | 1.8 % buil.<br>7.3 % vol. |
| | Av. val. | 135 m$^2$<br>2,055 m$^3$<br>52.4 % | Av. val. | 167 m$^2$<br>2,468 m$^3$<br>29.3 % | Av. val. | 265 m$^2$<br>4,756 m$^3$<br>49.2 % | Av. val. | 297 m$^2$<br>5,242 m$^3$<br>24.6 % | Av. val. | 834 m$^2$<br>17,571 m$^3$<br>14.1 % |
| **Level 3** | **3.I**<br>Vol. 3,500÷10,000 m$^3$<br>Adj. per. 40÷67 % | | **3.II**<br>Vol. 3,500÷10,000 m$^3$<br>Adj. per. ≤ 40 % | | **3.III**<br>Vol. ≥ 10,000 m$^3$<br>Adj. per. 40÷67 % | | **3.IV**<br>Vol. ≥ 10,000 m$^3$<br>Adj. per. ≤ 40 % | | | |
| | **17** | 3.1 % buil.<br>3.9 % vol. | **36** | 6.5 % buil.<br>10.5 % vol. | **3** | 0.5 % buil.<br>1.6 % vol. | **36** | 6.5 % buil.<br>34.6 % vol. | | |
| | Average values | 337 m$^2$<br>5,520 m$^3$<br>48.4 % | Average values | 425 m$^2$<br>6,967 m$^3$<br>25.8 % | Average values | 762 m$^2$<br>12,911 m$^3$<br>45.5 % | Average values | 1,284 m$^2$<br>23,027 m$^3$<br>18.0 % | | |

*Table 1: Categories proposed for the historic centre of Palermo*

## CONCLUSIONS

This investigation has applied the categorization method, developed in the EU project EFFESUS, to the historic centre of Palermo. The geometric features of the buildings, which the method is based on, have been expressed by means of two parameters: the volume, to represent the dimensions of the building units; the ratio between the shared and total ground floor perimeter, for the aggregation in the urban fabric. Through these terms, and referring to the limits the current urban plan of Palermo sets to preserve its architectural heritage, twelve categories have been defined. They have been collected in three groups, on the base of "levels of protection": three categories comprise the vernacular buildings, where refurbishment is allowed and the restrictions to the intervention are less (level 1); five describe the constructions for which, though the same measures are generally permitted, more limits derive from the need of conservation (l. 2); four refer to the monumental architectures, where restoration is required (l. 3). Other four categories have been eliminated since negligible in respect to volume and number of buildings.

The number of categories could require corrections if all the district were subject to further analysis. Anyhow, in this study the EFFESUS categorization has been adapted to the features of the historic architecture of Palermo and to the available data. Thereby, the applicability of the method has been examined and its integration to the typological structure of the current

urban plan is proposed: for this purpose, the existing typologies are detailed through the defined categories, more directly related to the dimensional, distribution and aggregation features of buildings. In this way, the possible strategies for the energy improvement of the historic architecture of Palermo could be included in the current framework of regulations pertaining to their conservation.

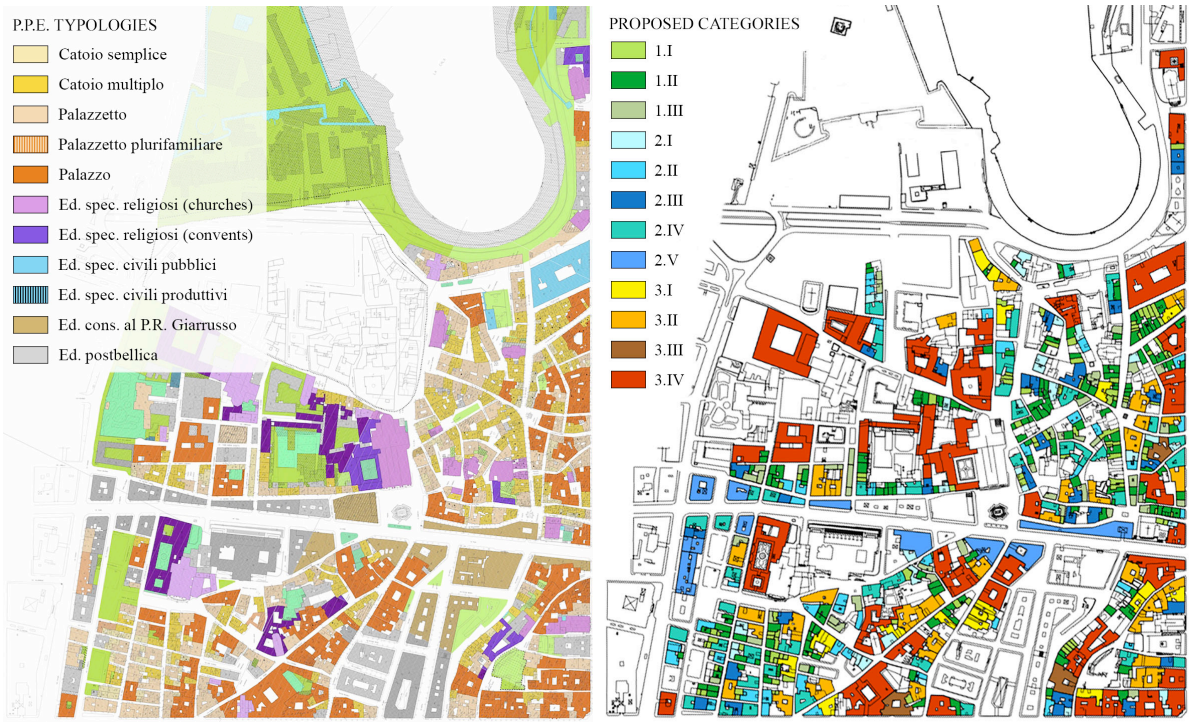


*Figure 1: Comparison between the P.P.E. typologies (left) and the proposed categories (right)*


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Our scientific partners from Cambridge University, the Massachusetts Institute of Technology and the Swiss Chapter of the International Building Simulation Association as well as the members of the CISBAT scientific committee and the session chairs have enthusiastically supported the conference and ensured its quality. We would like to express our sincere thanks for the time and effort they have spent to make it a success.

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Prof. Dr J.-L. Scartezzini
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