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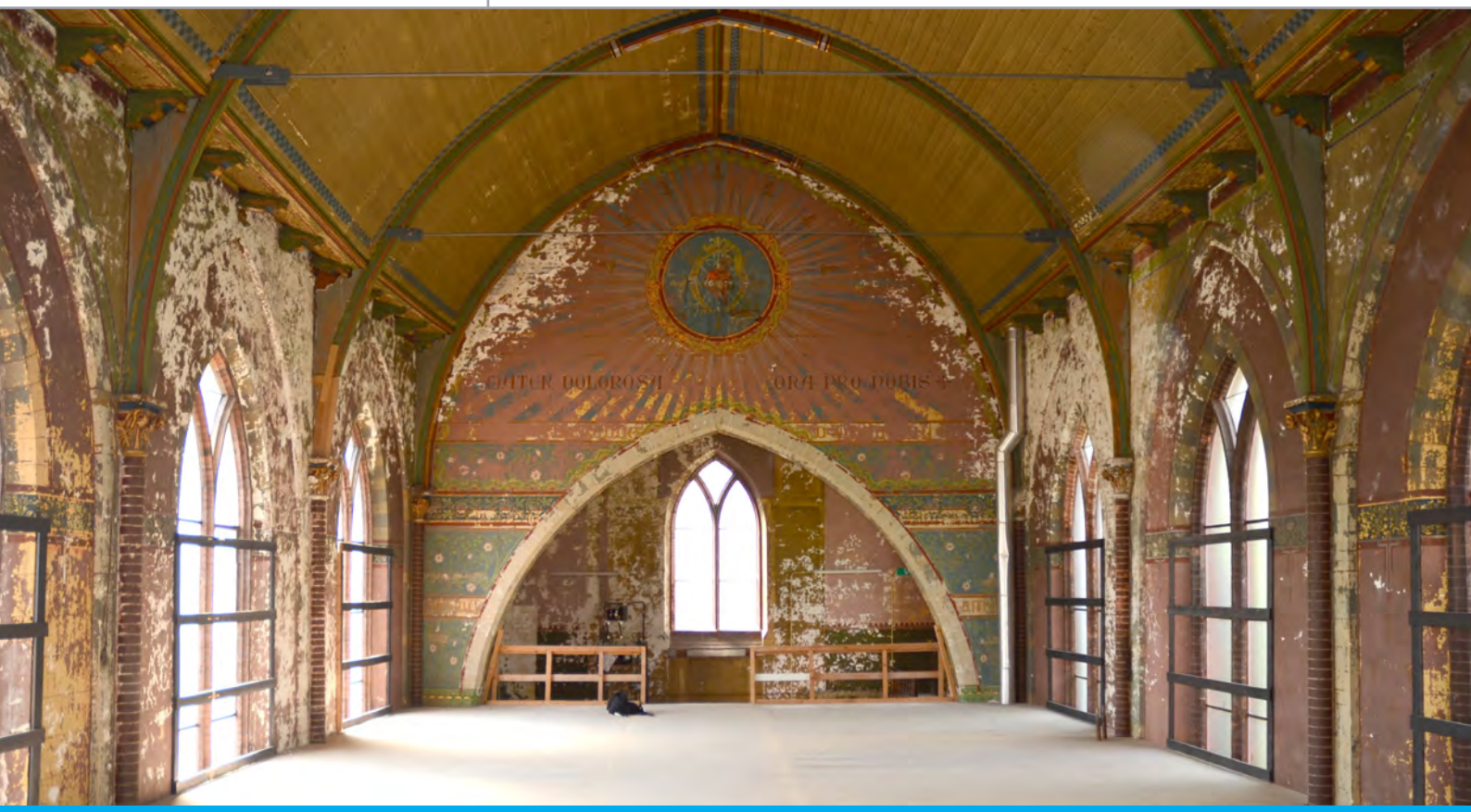

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TABLE OF CONTENTS

Friday 15 September

URBAN MICROCLIMATE: NATURAL VENTILATION AND OPEN SPACE IN THE HISTORIC CITY. SUMMARY OF CRITICAL EVALUATION ON THE ITALIAN AND INTERNATIONAL RESEARCH

Gaia Turchetti[1]

KEYWORDS

Natural Ventilation, Historic City, Integrated Conservation

ABSTRACT[2]

Analysing the city as a 'relations system', a reality, paraphrasing Edgar Morin [1], not only physical but also geo-psycho-bio-human in which humans must relate the manifestation of their own necessities and freedoms to the responsibilities related to them, one wonders what are the system inputs and outputs [2] that determine the processes and changes, conditions of comfort and discomfort - starting from a necessarily interscalar evaluation - of the city as a complex 'urban room'.

The difficulties concerning the ability to evaluate a multitude of contributing factors and the translation of these values into useful information on a practical level for crisis situations improvement (bearing in mind that knowledge of the factors, specifically the ventilation) vary, depending on the scale of the investigation and on the level of detail to achieve.

The natural ventilation is one of these factors that is often not calculated for its complexity and inconstancy; instead, natural ventilation results in positive effects on the extent of the heat island which differs in relation to the wind speed and the characteristics of the building's fabric. [4].

Remote sensing techniques and cartographic photointerpretation, according to Gis logic, computational simulation, the use of scale or empirical models or the realization of *in situ* measuring campaigns allows us to acquire data at various scales.

Nevertheless, it is necessary to apply simplifications and-or limitations of the investigation field, both deriving from instrumental or functional requirements, especially by relating to complex fabrics such as those historic. This begs the question: how much said simplifications influence the responsiveness of the model to the real data?

For this reason, part of my research has focused on the critical reading of professional literatures, interpreting some of the most important definitions with a wide design approach and considering what are the inputs and outputs of which knowledge is essential to locate a 'correct model' of air circulation, as synergistic product among various contrib-

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[2] The abstract reported here recalls some lines of the article: Turchetti, G. (2016). Microclima urbano: ventilazione naturale e ridefinizione dello spazio della città storica. In Talia M. (ed.), Un nuovo ciclo della pianificazione urbanistica tra tattica e strategia / A new cycle of Urban Planning between Tactic and Strategy, Planum Publisher, Roma-Milano.

uting factors. The main goal is to define a methodological analysis that aims to systematize the positive elements and minimize the problems of these methodologies, providing an expeditious support tool, that helps in the context analysis and in the definition of the first project phase, in view of a microclimatic improvement of the open space and even indirectly of the indoor ones of the '*città storica'* for an 'integrated conservation'.

INTRODUCTION

The natural ventilation study pertained to and still today is mainly about confined environments where the phenomenon is more easily controllable and manageable. This is the realm in which they have developed the first and main theories about the comfort[3] for environments built around man, initially 'ideal'[4] environments and then increasingly interdependent from the context, due to significant contributions, since the early fifties, from the Victor brothers and Aladar Olgyay and Baruch Givoni, and from the first adaptive theories introduced by Humphrey and Nicols since the seventies.

The single edifice is read as an obstacle placed in the open area and directly exposed to an undisturbed air flow, thus allowing to understand individual phenomena (shadow and wind wake, stagnation points, etc ...), that if analysed in an urban fabric would pile up and overlap in an extremely more complex way.

The increase in levels of urbanization and of the connected problems, however, has moved the axis of research and experimentation more and more to the urban organism scale with the definition of new assessment models of the ventilative phenomenon. These models are capable of analysing the airflows in the presence of a much more articulate 'weave', constituting the "urban fabric" and aiming at assessing the environmental factors, to paraphrase a famous line of St. Los [5], in relation to the technological system, climatic environment, distributive and figurative and also in relation to the architectural structure of the city.

NATURAL AND URBAN OPEN SPACE VENTILATION: STATE OF THE ART AND PONDERING POINTS.

Natural ventilation, as some studies show -including [4,6,7]- is the cause of positive effects on the size of the island that differ in terms of wind speed and building fabric characteristics, an aspect that strongly affects the definition of intensity and air masses direction. The wind speed threshold value beyond which the heat island dissipation effect is obtained, is also dependent on the extent of the urban agglomeration and also proportional to the number of inhabitants. Potential or negative effects on the urban fabric ventilation are mostly read with different eyes from those of the architect who will speak on space materiality. Still, today, you feel the lack of a support tool that helps architects or engineers in the defining the urban scale of the problem. Although the urban climatology

[3] The first ones were the studies conducted by the American ASHRAE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (formed by the merger in 1959 of the American Society of Heating and Air-Conditioning Engineers ASHAE, founded in 1894, and The American Society of refrigeration Engineers ASRE, founded in 1904) (www.ashrae.org) with contributions by the Danish P.O. Fanger that processes, as a result of a climatic chamber experimentation, the evaluation indexes of the wellness of the individual (PMV - predicted mean vote- and PPD -predicted percent dissatisfied-) taking into account subjective and indoor environmental variables.

[4] The first assessments of the environmental conditions of indoor spaces, dating back to the first twenty years of the twentieth century, narrowed the problem only to the internal parameters of temperature, humidity and air velocity, without considering any contribution of external factors on the studied environment.

theme is covering over the last 10-20 years a leading role in research, also architectural, on solutions on environmental adjustment/mitigation (just think of the line of research of new low-emission materials and/or permeable and the theme the design or redesign of the urban green space or green infrastructure), the study of the air masses movement and the contribution that can provide for the mitigation of urban open space "takes the backseat" and it doesn't touch, if not in an extremely marginal way, the architecture field.

In the urban field, the degrees of difficulty in understanding the ventilative flow and other factors related to environmental issues (already known in the indoor field) exponentially increase and it is evident the necessity not to use evaluation parameters calibrated on 'absolute values' but 'related' to the single entities involved[5]. At this scale, where single canyons constitute the walls of the urban room and where coverage is characterized by the closest layers of the atmosphere -the so-called canopy and boundary layer-, it prevails the line of research that exploits the knowledge on the progress of urban scale flows for the design or the redesign of the built plant. In particular the interaction between the single building or group of buildings with the urban area in which it is comprised. Significant was, at this juncture, the contribution of the Urbavent project (2001-2003) [8] that has its roots in the previous Naturvent project of the late nineties. The project has addressed the issue of strengthening of natural ventilation as a tool for the reduction of energy consumption for buildings located in urban areas, including the significant effect of the increase in the urbanization level of the European territory – estimated by now at about 75% with a ten-year increase of 3% - which is mainly due to the reduction of the flows potential in relation to the increase of the barrier elements and of the problems connected to the surface roughness of the urban space. In the context of this project, interesting studies have been conducted on the ventilative factor in the city of Athens that led to the definition of the wind strength theoretical calculation model in an urban canyon, embedded in an instrument called by the same name of the project: Urbvent. The proposed analysis methodology in the existing (but spatially limited) urban context has allowed to identify specific problems of this complex scenario and sought to respond to the lack of support tools that would help architects and engineers interpret the ventilative phenomenon during the design.

So far, we remain within the sphere of the single building or building front, stressing the predominance of the built space over the open one, which, although being co-participant in the definition of urban organism as the location of the active flows of city life, it remains a theme into the background[6].

From the early years of the 21st century to the present time, much has changed in the field of research and experimentation on the theme, thanks mainly to the evolution of

[5] Especially in the last fifteen years, studies are being developed that seek to evaluate whether and how to use, modify the 'traditional' comfort indexes or define new ones to be applied in the outdoor field: from the PMV and PPD indices, to PET and UTCI, specifically designated for the Mediterranean climate (MOCI). [9]

[6] Though it concerns a parallel field to the one discussed here, a short point should be made with reference to experiments and projects that concern the open space of the city by assessing the indirect use of ventilation as a source for energy production for the consumption reduction. We think, for example, about the theme of the introduction of micro-wind and windmill systems in existing fabrics: from the Abres à vent-New Wind by Jérôme Michaud-Larivière project, to the Vibro-Wind project proposed by Cornell University. But we also remember the experimentation conducted at the Universal Exhibition in Seville in 1992 where 12 wind towers were placed in the open space between the various pavilions, resuming the 1992 Arab tradition or the towers designed in Madrid and Shanghai by the Urban Ecosystem.

techniques and technologies that have allowed us to achieve unprecedented results in such a short time.

Remote sensing techniques, for example, which are "mainly based on the combination of (statistical) image classification and the visual interpretation of Very High-Resolution satellite imagery" [10], enable us today to get an overview of the urban ecosystem in its entirety. For example, think of the Urban Atlas of the European Environment Agency (EEA), which is part of the GMES/Copernicus monitoring services. The Atlas provides a useful database for understanding the characteristics of the urban body, including some environmental factors, of nearly 700 major EU cities [11], providing useful information for decision-making on issues related to climate change. Undoubtedly, this data is essential to understand and locate the most vulnerable areas of each city and to define an action strategy that is as close as possible to the real needs and peculiarities of the site. [12].

But, whilst it is recognized the paramount importance of these data for the activation of strategies and plans at the meso-scale and local scale, the accuracy of the data provided by these tools, linked in particular to spectral and spatial resolution of the sensor [13], does not allow us to analyse it in further detail. Once located the macro area of intervention, other tools must be entrusted to fully understand the multiplicity of competing factors in the environmental definition of the examined area.

If we focus on the specific ventilation theme, on traditional instruments, from measurement campaigns on-the-spot to the use of empirical or wind chamber[7] scale models, they are now complemented by computational tools based on microscopic analysis models, also known as CFD (computed fluid dynamics), also integrated in some software that allows a holistic reading of the various competing factors in the definition of comfort, or rather urban discomfort. These tools help to discretize the actual figure by comparing it to ever smaller and more precise geometric meshes [15], offering an almost 'immediate' reading of various climatic factors, some of which are difficult to instrumentally measure. Conversely, these tools need a simplification of the morphological and structural data of the software itself and have a response time that directly increases in proportion to the increment in the survey area and the complexity of the fabric that is to be analysed.

It is therefore reasonable to ask how much the limitations of the computational model affect the correspondence of simulated data with the actual one. A few researches, albeit significant in the international landscape, seek to analyse the reliability of the simulated value compared to the real one, with particular attention to the evaluation of the ventilative factor. The wind speed value provided by the virtual model is in many cases divergent from the actual data and, specifically, mostly underestimated in the city historic center fabrics and overstated in the $19^{th}/20^{th}$ century expansion areas [16,17].

This demonstrates that fluid-dynamic computing tools need to be integrated with the most traditional in situ measurement systems, if only for validating the model in view of its use to prefigure future interventions scenarios.

The theme is more cogent if we focus on historic and consolidated fabrics, characterized by a high morphological and morphometric complexity.

So, the important issue of urban space has to be analysed: so far, in this short dissertation about the city, we defined it as that part of new or existing urban fabric that is subject to substantial redefinition. This is because most research and experimentation, if not almost all, focus on this part of the fabric by neglecting or treating only marginally the his-

[7] The wind chamber flow simulation allows us to choose the desired definition, depending on the scale of the model, but does not allow us to evaluate the thermal inputs resulting from the superficial surface characteristics. [14].

toric city[8], namely that part of town characterized by urban fabrics that, of medieval origin or of 19th/20th century expansion, must be protected for its historic and cultural value.

For example, the empirical models, which usually synthesize the aspect ratio of an urban area, from those of Ellefsen to those of T.K. Oke [18-20], are based on overseas urban realities (large Megalopoles characterized by mainly rectilinear canyons, large variance of the altimetric built factor, the building density extending vertically rather than horizontally, etc ...) that exemplify a reality far distant from the European model, and specifically Italian, of the city.

In the Italian landscape, apart from some studies in which the environmental conditions between new cities and historic ones are compared or some interesting experiments conducted on consolidated fabrics, such as those proposed in the REBUS® project - acronym REnovation of Public Buildings and Urban Spaces promoted by the Emilia Romagna Region - or in the Manual for the Reduction of the Heat Island Phenomena promoted by the Veneto Region [21], or hints on the importance of the ventilative factor at the guidelines level, but specific to the historic building rather than to the public space[9], Ventilation in the open space of the historic city is not subject to a specific analysis. Yet it is all the historic fabric of most cities to be most vulnerable to climate change and to suffer from rising temperatures. Undoubtedly, the degree of freedom of intervention in these areas is greatly reduced, but it is also worth investigating the ventilative phenomenon, along with the most commonly studied factors, and understanding whether and how ventilation can positively contribute to the environmental improvement of consolidated and historically protected spaces, also with 'minimal intervention'.

THE IMPORTANCE OF A QUICK EVALUATION: CRITICAL CONSIDERATIONS AND PRESENTATION OF THE RESEARCH WORK.

From this summary of the state of the art on the research subject, just briefly presented here, it is clear that we must start from the basics and recalibrate the analysis tools that are usually conformed to other city models, in order to understand the ventilative problem in complex fabrics, such as those historic.

The aforementioned problems, pertaining the scale of investigation and the instrumentation to adjust to it, are exacerbated by analysing the *città storica* so defined, and there is the need to re-read what literature has bequeathed and evaluate what changes to make, so that, both in the learning phase and in the evaluation phase, we have the necessary tools to propose intervention scenarios closer to the reality of such spaces.

Fundamental issues emerge, so closely related to each other, and which have been the starting point of my research.

The sampled reality is the one that defines the historic fabric of the city of Rome.

They started from the understanding of the environmental characteristics of the Capital through the collection of major climate studies, from the early studies of Colacino and

[8]Today, it is no longer a historic center, but a historic city as well as "those urban settlement structures that constitute cultural unity or the original and authentic part of settlements and witness the character of a vibrant urban culture [...]" (Commissione Franceschini 1964 - Dichiarazione XL) extended to all the fabrics typical of medieval *facies* but also to the eight-twentieth-century expansion that have a strong identity value.

[9] Such as the Energy Reconstruction Guidelines for Historical Heritage elaborated under the A.T.T.E.S.S. project.

Lavagnini to the latest bulletins provided by the CRA-CMA[10] or recent university researches, such as those of the Department of Civil, Constructional and Environmental Engineering or the Department of Astronautics, Electrical and Power Engineering (La Sapienza, University of Rome), just to name a few.

At the same time, the analysis of the specific morphological characteristics, and above all the morphometric characteristics of the city, has been investigated to recalibrate its parameters.

At this most theoretical stage, a field experiment has been carried out, envisioning an on-site measurement campaign, on selected areas among those that have the highest degree of vulnerability in the historic fabric [22]. These data, directed at the pedestrian level, were coupled with the direct data collected by the weather station that could best describe the influence of the urban plant on the anemometric characteristics: the Collegio Romano Station[11].

This collected database has allowed to validate the simulated data, this time specific for the Capital fabric, an extremely important step for the next phase of the intervention.

On an experimental model, defined especially for this research, possible intervention scenarios were tested, focusing on project planning above all on those aspects of the urban plant that can most influence the ventilatory factor, water above all, with the aim of mitigating the unfavorable environmental conditions recorded. The final point of the research is through a trial and error process that is based on a continuous validation of the data, the definition of a methodology for quick study that can systematize the various tools used in order to obtain a fast planning response. A methodology that proves itself flexible (adaptable to the heterogeneity of the facts), iterable (easily repeatable on different cases), implemented over time and which can respond to the lack in the technical, procedural and regulatory field.

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[11] Weather observations Collegio Romano CREA-CMA (Research Unit for Climatology and Meteorology applied to Agriculture - formerly UCEA) Piazza del Collegio Romano, Rome. It is worth pointing out that the data provided by a meteorological station located within the urban fabric compared to those provided by extra-urban meteorological stations - which are usually located in airport areas as they record inflections of environmental factors that accurately describe the climatic conditions of the urban plant – are more precise.

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After successful events in Leuven (2009), Brno (2011) and Stuttgart (2014), WTA Nederland-Vlaanderen and the chair of Heritage & Technology at Delft University of Technology, Faculty of Architecture and the Built Environment host the 4th WTA International PhD Symposium from 13-16 September 2017 in Delft, the Netherlands.

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