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Revealing the thermal environmental quality of the high-density residential tall building from the Brazilian bioclimatic modernism: The case-study of Copan building

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ABSTRACT

Looking back to the glorious years of Brazilian modernism between 1930 and 1964, the countryś architectural heritage reveals an environmental design approach still relevant to buildings of today. In this context, the COPAN building (1966), located in São Paulo (latitude 23°S), is one of the most iconic buildings of its time with 1.160 residential units encompassing various types of studio flats (called in Portuguese "kitnets") as well as one, two and three bedroom apartments distributed across six blocks of independent vertical circulation accesses. This naturally ventilated tall building is recognized by its massive concrete curvilinear structure of 140 m high, shaded towards the north and northwest orientations by horizontal concrete *brise-soleis* and opened with a single glazed curtain wall on the south and southeast orientations. The thermal performance of the Copan building was investigated by means of fieldwork and analytical procedures. The fieldwork included measurements *in loco* of environmental variables in four residential units, during warm and cooler periods of the year (2016) and interviews with a sample of 100 occupants, this was followed by thermal dynamic computer simulations performed with the Thermal Analysis Simulation Software (TAS). The adaptive comfort model defined in ASHRAE 55-2013 was adopted as the performance criteria for analytical studies. One of the main conclusions of these technical studies was about the combined effect of thermal inertia, external shading and controlled natural ventilation resulting in steady thermal conditions, with air temperatures oscillating between 24 °C and 26 °C when external temperatures reach as high as 32 °C in a typical warm afternoon.

1. Introduction

Looking back to the glorious years of Brazilian modernism between 1930 and 1964, the countryś architectural heritage reveals an environmental design approach still highly relevant to buildings of today. Architectural design of residential buildings, in particular, paid attention to solar orientation and the consequent need for solar protection as well as to thermal mass and natural ventilation. Horizontal and vertical *brise-soleis*, external movable wooden shutters and perforated ceramic blocks were typical shading elements of curtain wall façades with multiple openings for natural ventilation, whilst the common concrete structures of modern architecture added thermal inertia to internal spaces [12]. The distinguishable and creative manner by which principles of environmental design were introduced in referential buildings from the Brazilian modernism produced between 1930s and 1960s made the architecture from this period known as the "*Brazilian Bioclimatic Modernism*".

In the city of São Paulo (latitude 23°S), the modernist architecture was widely applied to residential tall buildings of various heights starting from 9 stories and reaching more than 30 stories in some cases, most of them built in the historical city centre and its surrounding neighbourhoods. One of the most iconic residential buildings of the apogee of Brazilian Modernism is the COPAN building, located in the heart of the city of São Paulo, designed by Oscar Niemeyer and Carlos Alberto Cerqueira in 1950s and completed in 1966. This iconic modernist tower is recognized by its 140 m-high curvilinear concrete structure of a gentle "S" shape, shaded towards the north and northwest orientations by horizontal concrete *brise-soleis* and opened with a single glazed curtain wall on the south and southeast orientations.

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Fig. 1. The residential tall building COPAN, 1966, in the city centre of São Paulo, North and Northwest orientations.

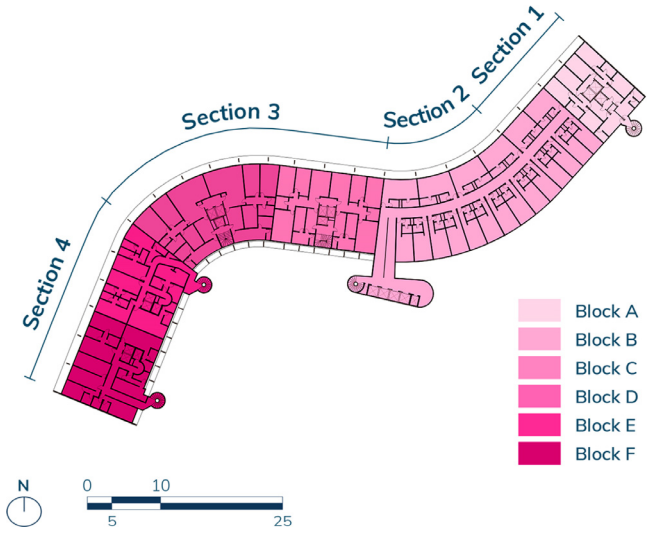

Fig. 2. On the right, typical floor-plan of the COPAN building.

The verticalization process of São Pauloś city centre was initiated in the first decades of the 20th century, as a consequence of economic growth and urban development [8,10]. The building regulations for the city centre valid between 1930s until late 1960s (named *Código de Obras Arthur Saboya*) made mandatory that buildings were aligned with the edge of the sites. In addition to that, height was associated with the width of the street, as happened in other major urban centres of the world, such as New York and Berlin.

Buildings facing streets which were between 9 and 12 m wide could be as tall as twice and a half the width [9]. Despite the height restrictions of urban regulations of those days, permission was given to the COPAN building, in order to allow the creation of a landmark and an icon of modernity and urban density in one of the most economic prosperous cities of the continent at that time (see Fig. 1). Due to its size slab-like shape and facade treatment, the COPAN building was compared by the international architectural community with other icons for social and affordable housing from the European modernism of its time, such as the *Unite d'habitation* in Marseille, France (1952).

Already in those days, urban development and verticalization in the city centre of São Paulo were associated with high density and compact housing (Sampaio, 2004). Many tall buildings were designed to accommodate studio flats name by the local building sector as *kitchenettes* or simply *kitnet,* which were residential units varying from 14 m^2 (the size of a hotel room) to 28 m^2, approximately. In these compact units kitchen appliances were compacted in an area attached to the living space. In the socioeconomic context of the city of São Paulo, those units are still associated today with affordable housing. The tall and elongated "S" shape of the COPAN building has four variations of the so called *kitchenette* typology, with distinguished sizes, space layouts, orientations and facade treatments. In the first decades of the 21st century, both public sector and the real state market have had to respond to pressures from housing demand in the city centre, what made the kitchenette typology an attractive economic solution in old retrofitted buildings or in new ones.

The design process of buildings from the bioclimatic modernism was based on the knowledge of environmental principles but without the resource for fieldwork and the analytical tools of today. Until now, very little is known and publicized about the environmental performance of those buildings and the specific architectural solutions applied to deal with the local conditions of the subtropical climate of São Paulo and allow occupants to adapt to the daily and seasonal variations, whilst adding architectural identity to the tall building typology. Having said the above, this work is based on the premise that the architectural features of the modernist bioclimatic residential tall building in São Paulo hold thermal qualities still valid for the architecture of the present time and which have not yet been characterized and quantified. Hence, the objective of this technical study is the assessment of the thermal performance of a few selected residential units in the COPAN building, by means of fieldwork and analytical work carried out with the use of thermodynamic computer simulations.

2. The case-study building

The COPAN is the tallest residential buildings in South America with 42 floors and 120 thousand square meters of total built space. Commissioned by and named after the Pan American Company of Hotels (*Companhia Pan Americana de Hotéis, COPAN)*, the building is currently occupied by 5.000 people, living in 1.160 residential units encompassing various types of studio flats (kitchenettes) as well as one, two and three bedroom apartments distributed across six blocks of independent vertical circulation accesses (see Fig. 2) [3,5].

Block A encompasses 64 two-bedroom apartments, whereas in blocks B, E and F there are 968 residential units including kitchenettes and one bedroom flats. Adding to that, blocks C and D accommodate 128 three-bedroom apartments (of approximately 130 m^2). The studio flats are concentrated in block B, with the shallower ones which have the wider facade located at the north side with 30 m^2, and the deeper ones with the narrower front at the south side with 25 m^2 (see Figs. 2 and 3). The variety of residen-