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THE NEW WORKING ENVIRONMENT: ENVIRONMENTAL DIVERSITY AND FLEXIBILITY OF SPACE

Abstract

The environmental impact followed by the energy demand and comfort and health issues of the glass-box building with artificially conditioned spaces inspired, in the beginning of the decade of 1990, of new architectural paradigms for the office building. However, it is worth mentioning that the considerations to natural ventilation and daylight were already present in the iconic buildings from the first decade of the international modernism. In Brazil, the modernist architecture produced between the decades of 1930 and 1960 is globally recognized for its relationship with the local climate, sun, daylight and natural ventilation and, for this reason, was qualified by many architectural reviewers as Bioclimatic Modernist Architecture. But it was only since the last decades of the 20th century that the acknowledgement of the positive effects of more flexible and informal environments upon the productivity and satisfaction of the occupants led to the insertion of transitional spaces in the design of office buildings. These architectural changes are part of a more flexible notion of environmental comfort. Parallel to that, the evolution of information technology, added to the appearance of the so called *knowledge economy*, introduced new trends to the occupation patterns and routines in the working environment that value spaces qualified by vegetation, informal areas, visual communication between interior and exterior and daylight, resulting in interior spaces more opened to the exterior. Based on the notion that the office of the future offers a working environment rather than a desk, the critical review of theories and case-studies presented here suggests a definition of the working environment in which a set of alternative spaces such as balconies, gardens, terraces, atriums and others are added to interior spaces and become recognized potential spaces to the diversity of activities that constitute the new offices of the XXI century.

Keywords

Architecture. Working environment. Environmental quality. Spatial flexibility. Diversity.

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O NOVO AMBIENTE DE TRABALHO: DIVERSIDADE AMBIENTAL E FLEXIBILIDADE DO ESPAÇO

Resumo

O impacto ambiental, acompanhado pela demanda energética e pelos problemas de conforto e saúde nos edifícios da caixa de vidro e do ambiente artificial inspiraram, no início da década de 1990, a criação de novos paradigmas arquitetônicos para a tipologia do edifício de escritório. Porém, vale destacar que as considerações para com a ventilação como iluminação natural eram marcantes já nas obras ícones das primeiras décadas do modernismo internacional. No Brasil, a arquitetura modernista produzida entre as décadas de 1930 e 1960 é reconhecida mundialmente por sua relação com o clima, o sol, a luz natural e a ventilação, e por isso, qualificada por muitos críticos como Arquitetura Modernista Bioclimática. Mas foi apenas a partir das duas últimas décadas do século XX que o reconhecimento dos efeitos positivos dos ambientes mais flexíveis e informais na satisfação e produtividade dos ocupantes levou à inserção de espaços de transição no projeto de escritórios. Estas mudanças arquitetônicas fazem parte de uma noção mais flexível de conforto ambiental. Paralelamente, a evolução das tecnologias de informação, somada ao surgimento da chamada *economia do conhecimento*, introduziu novas tendências para as rotinas de uso e padrões de ocupação do ambiente de trabalho, que valorizam espaços qualificados pela vegetação, áreas informais, comunicação visual entre interior e exterior e luz natural, resultando em ambientes que se comunicam com seu entorno. Partindo da noção que o escritório do futuro oferece um *ambiente* e não uma *estação de trabalho*, a revisão crítica de teorias e estudos de caso aqui apresentada sugere uma definição de ambiente de trabalho em que um conjunto de espaços alternativos como varandas, jardins, terraços, pisos de átrios e outros, somam-se aos espaços internos e tornam-se, reconhecidamente, espaços potenciais para diversas atividades que constituem os novos escritórios do século XXI.

Palavras-chave

Arquitetura. Ambiente de trabalho. Qualidade ambiental. Flexibilidade espacial. Diversidade.

Introduction: brief historical overview

The environmental impact and energy costs associated with the occupation and operation of the sealed glass box office building, massively and recklessly reproduced around the world in the second half of the 20th century, coupled with the comfort and health problems of the occupants, resultant from the artificial environment, inspired in the beginning of the decade of 1990, the creation of new architectural and environmental paradigms. These alternative ideas for the new office buildings tackled not only the issue of energy demand in the operation of these buildings, but also offered an architectural response to the influence of a new emerging working culture, social dynamics and concepts of environmental quality for the office building.

Some of the most internationally recognized buildings, which are icons of this architectural generation, are the headquarters of the Commerzbank, in Frankfurt am Main (1998) and the one that was built in the main building of one of the largest insurance companies in the world, the Swiss Re (2004), in London, buildings that will be analysed in more detail in this text. However, the ideas about the environmental quality and climatic considerations of the office building is long prior to the 1990´s generation, dating back to the early decades of the 20th century.

Up to 1950´s, the artificial conditioning of internal spaces, mechanical ventilation and artificial lighting were not present in office buildings in cities such as New York and Chicago, some of the main urban centres for technical and building innovation in the world at that time (WILLIS, 1995). Even in the tallest buildings, as the Empire State Building (1931), in New York, were design with operable windows for natural ventilation, alongside the considerations to daylight. Besides, due to the structural limitations, the narrower plans (compared with todays´ buildings) facilitated the penetration of daylight and natural ventilation.

The considerations towards the environmental quality regarding both daylight and natural ventilation had a significant role in the iconic architecture of the first decades of the international modernism. For example, the office building Johnson Wax Building (1950), in Racine, USA, designed by Frank Lloyd Wright, in its horizontal form and multiple floor up to the ceiling height, replicating the spatial configuration of a factory, has a translucent roof over the whole usable area of the wide horizontal shape, bringing daylight to the interior.

In Brazil, the modernist architecture from between de decades of 1930 and 1960 is recognized worldwide for its climatic insertion, dealing with the sun, daylight and natural ventilation and, for this reason, qualified as Bioclimatic Modernist Architecture (RUSSO, 2004). One of the main achievements of the Brazilian modernist architecture, still in the first half of the 20th century is, certainly, the Gustavo Capanema building (1936), in Rio de Janeiro, the headquarters of what was then the Ministry of Education, Culture and Health, known as the MEC building, designed by a team led by Le Corbusier in collaboration with the Brazilian architect Lúcio Costa (figure 1).

Figure 1: View of the northern facade of the MEC building (1936), Palácio Gustavo Capanema, Rio de Janeiro, with the movable horizontal shading devices. Photo: João Leal.

The MEC building follows the standard of the rectangular block of multiple storeys placed on *pilotis* and oriented towards north-south approximately, being the main facades of the curtain wall type with operable windows. The Northern facade is completely shaded, whilst the Southern one is entirely exposed to the sky and solar radiation. East and West orientations have blind walls. As known, the design process of the Bioclimatic Modernism seen in the second half of the 20th century not only in Brazil but globally, that produced buildings like MEC and many others in Brazil and abroad, was based on principles from the building physics science and basic tools such as manual calculations and the solar chart for solar geometry (BANHAM, 1984; HAWKES, 2008).

Nevertheless, it is important to say that, in general, the bioclimatic modernism practiced around the world produced deterministic rules constraint to a set of forms and architectural components that, despite their climatic logic, simplified the issue of environmental performance in buildings. The problems related to the oversimplification is clear in the case of the external shading devices in the MEC building, in which the shading of the **N-NW** facade makes the interior spaces dark and blocks external views, at the same time that the southern side of the building, oriented S-SE (160o), unprotected from the sun, suffers with higher temperatures than the ones in the northern side, due to the impact of solar radiation, as seen on the fieldwork conducted by Corbella and Yannas (2003). In the latitude of the city of Rio de Janeiro, 23º S, the **S-SE** facade receives direct sun for longer periods of the morning in the summer months, however, no strategy for solar protection was adopted for this particular facade in the MEC building. Even the Brazilian Bioclimatic Modernism, which was rooted in climatic strategies, had a strong formalistic approach, including the brises and the curtain wall, among other architectural features.

On the other hand, it should be recognized that buildings as MEC are architectural symbols of an era that expressed with majesty the synthesis between aesthetic and environmental values, as well as the technological possibilities of its time, containing timeless spatial and construction attributes for the environmental quality of internal and external spaces, which are of great use to architecture and urban design. With regard to the building design, in the case of the MEC building, one could mention the narrower plans for daylight and natural ventilation, the external shading devices on the northern side, operable and controllable windows and the vegetated terrace on the Southern side, which offers a direct connection between indoors and outdoors to the occupants, when the external climate is mild. The ground floor of *pilotis* offers protection against the sun and the rain of the tropical climate to the pedestrians, and the planning of

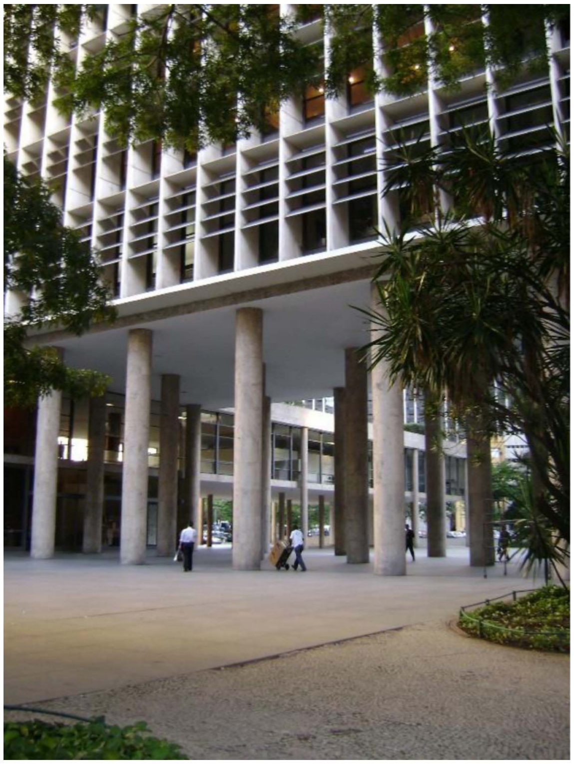
Figure 2: Ground floor of the MEC building showing the open-access shaded pedestrian area protected by the pilotis. Photo: Joana Carla Soares Gonçalves.

the slab block location, placed across the urban block in an area of compact surrounding urban blocks, creates an open space like a square, away from the streets´ environment, a kind of urban oasis.

It is interesting to mention that this was the first building in the world to put up the so called "curtain wall", which later resulted in the architectural movement known as the International Style and the proliferation of the glass box building. Some of the most well-known glass towers of the apogee of this architectural movement are the Lever House (1952), designed by Skidmore Owins and Merril (SOM) and the Seagram Building (1958), by Mies Van der Rohe, both in New York. Different from the MEC building, these North-American examples built nearly two decades later, marked the beginning of the era of systems´ dependence and the culture of fully air-conditioned environments.

The culture of the working environment in 1950s and 1960s, within the rectangular space of the metallic box of massive steel and / or concrete structure, reflected the *Fordist* thinking, in which the layout of the workstations reproduced the sequence and the linearity of the machines in a conventional factory, following the logic that the positioning of the people was based on the movement of the paper work (ANDRADE, 2007). At the same time, the glass box building introduced the scenario of the controlled environmental conditions, restricted by a tight range of internal temperatures, justified by the thermal comfort theory developed by Fanger (1972), with his PMV index (Predicted Mean Vote). The PMV index stipulates the mean vote of a group of people according to a scale of thermal sensation containing 7 points (-3, -2, -1, -0, 1, 2, 3), representing: "very cold", "cold", "neutral", "warm", "very warm", respectively.

The mathematical model created by Fanger (1972) relates to the difference between the real heat flow of the human body in a specific environment and the necessary heat flow (heat loss) for the body to achieve its physiological comfort for a specific activity. Until today, the Fanger model is widely applied and accepted to the evaluation of thermal comfort conditions in air-conditioned spaces, including a huge number of office buildings in different parts of the world. This model was adopted by the American Society of Heating, Refrigerating and Air Conditioning Engineers, ASHRAE, in its technical standard for building´s thermal and energy performance, ASHRAE 55, which has been revised and up-dated three times since its first edition in 1992 (1992, 2004, 2010, 2013).

In 1960s and 1970s, the poor environmental quality of the noise and polluted urban space of big cities that grew with the concentration of people, accompanied by economic and anthropogenic activities, generated the perfect context for the justification and dissemination of the sealed building, entirely dependent on systems for the conditioning of the internal spaces. However, curiously, in this same period, the model of the office building of the glass box and totally controlled environments gained environmental perspective in the futuristic propositions of Buckminster Fuller and Norman Foster, in projects for cities in North America and the United Kingdom.

In 1961, Buckminster Fuller proposed the utopian project of the Geodesic Dome City, with a cupula over the island of Manhattan, extrapolating the concept of the artificially controlled environment in buildings to the urban environment as a whole. One decade later, in 1971, Fuller and Foster developed a conceptual office building entitle *Climatroffice*, still artificially conditioned, literally like a bubble, but with a strong presence of vegetation and ample visual communication between inside and outside (SUDJIC, 2010). The architectural design of the headquarters of the company Willis Faber & Dumas, designed by Foster and Partners and built in 1975 in the city of Ipswich in the UK, was then based on the concept of the hypothetical *Climatroffice*, of a curvilinear shape with a glass envelop and internal environments artificially conditioned (figure 3).

Between 1980s and 1990s, the culture of the working environment has undergone several changes reflecting in changes of layout and configuration of internal spaces, as described by Harrison, Wheeler and Whitelead (2003). During this process of change, there was a return of the cellular office and the appearing of combined arrangements with closed rooms alongside open-plan

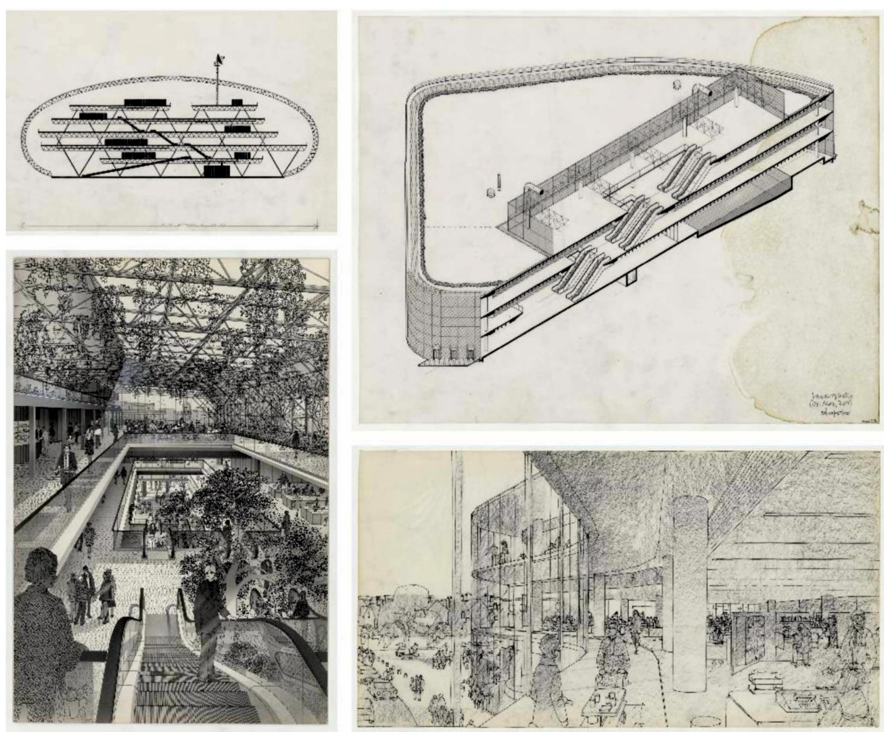

Figure 3: In the top left corner, schematic section of the Climatroffice project (1971). In the top right corner, an axonometric perspective of the Willis Faber & Dumas design Project (1975), showing the internal void created by the vertical circulation and the central atrium and the parts of the building systems including mechanical ventilation, cooling and heating. In the bottom left and right, drawings of the interior spaces highlighting the ambience created by the vegetation and the idea of visual communication between inside and outside in the Willis Faber & Dumas building. Source: Images provided by the Norman Foster Foundation Archive, Madrid.

areas, creating what would be called the combi-offices. Nevertheless, these changes did not affect either the economic logic and values that defined the form and facade treatment of the conventional office building, neither the consolidated culture of the artificial environment. This period also marked the evolution of glass technology and performance with special attention to the shading coefficient and visual transmittance, which was proved not to contribute with a significant improvement in the thermal performance of buildings, as seen in a number of analytical studies including the ones carried out by Marcondes (2004).

It was only since the last two decades that the positive impact of informal spaces on socialization and productivity of occupants was recognized, leading to the re-appearance of transitional spaces and outdoor areas in the design of the office building, regardless of their climate context. The insertion of atriums, patios, balconies and terraces is part of the growing understanding about the notion of a more flexible comfort zone, based on the adaptive model theory, in which, in a few words, the indoor comfort is directly related to the external climatic conditions.

It is interesting to note that Humphreys (1976) initially proposed one of the first adaptive models for thermal comfort in the decade of 1970, at the same time of the Fanger comfort theory. Obviously, the notion of comfort for the naturally ventilated working environments was not appropriate to the typology of sealed office building and the economic logic of the building sector of that time, whose interest was the popularization of air conditioning systems.

The concept of adaptive comfort was re-introduced by the scientific community as well as by the building industry in the beginning of the 21st century. As explained by Monteiro (2015), results from fieldwork carried out by Nicol and Humphreys (2002) showed that stationary models, such as Fanger´s PMV, are not precise when predicting the real level of satisfaction of the occupants with their thermal environment, super estimating the discomfort, especially in variable conditions, in other words, in those spaces where windows are operable. Another example in this same sense is the research carried out by Brager and De Dear (2004) with 230 occupants of Berkeley Civic Centre office, where most occupants want more air circulation in their workspaces.

The fact is that since the second half of the 20th century, a huge stock of office buildings has been built, from which the energy consumption associated with the dependency on cooling systems is accompanied by growing alarming rates of CO_2 emissions, which tend to grow. In the year 2000, the global stock of residential and commercial buildings accounted for 60 per cent of all electricity produced worldwide (IEA, 2009; LAUSTSEN, 2008; Levine et al 2007; WBCSD, 2007). In addition to that, there is the problem of the internal air quality in sealed buildings, which was made clear with the identification of what was called the sick building syndrome, originally found in buildings in the 1980s (JAN and STOLWIJK, 1991).

In global terms, the consumption of electric energy in office buildings tends to increase with the growth of the building sector projected into the near future, mainly in parts of the Far East Asia and the Middle East (UNEP, 2011). The predominant warm and hot climates of these regions is an aggravating factor for the demand of space cooling. On the other hand, as it has been said for almost a decade by research specialists, practitioners and even international institutions, such as the United Nations Environment Programme (UNEP, 2011), the potential for energy savings in the model of the conventional office building is also significant today and in the years to come. This is simply because the internal spaces in these buildings are artificially fully air-conditioned, during all occupancy. For this reason, the model of the sealed glass box has a great potential for improvement, with a lot to be explored with regard to climatic considerations, in particular with regard to the reduction of solar gains.

In this way, for several years, in the North American scenario, characterized by the emphasis on building systems and technology, a research carried out in 5.375 office buildings showed that the use of energy efficient lighting and air conditioning systems, coupled with the shading of facades, has the potential to reduce 64 per cent of the energy demand associated with cooling of the internal spaces (GRIFFITH et al. 2006). In the United Kingdom, guidelines to energy conservation in buildings point out to a potential reduction of approximately 60 per cent of energy demand of fully air-conditioned commercial buildings, as a factor of the introduction of natural ventilation (CIBSE, 2004).

Architecture of better environmental performance and the icons from the decade of 1990

As mentioned in the beginning of this reflexion, in the turn of the 20th century, a new architectural paradigm for the so-called environmental office building was created as a result from the global pressures regarding the high-energy demand in the building sector and the recognition of the issues related to the environmental quality of artificially controlled spaces. Such paradigm re-introduced daylight and natural ventilation in the working space (GONÇALVES, 2010).

Iconic examples of this generation of office buildings were conceived based on the premise that an appropriate base-case building for an efficient thermal performance starts with good daylighting conditions. This is due to the heat loads from artificial lighting systems and the well-known daylight quality when compared to artificial light. The impact of daylight in the perception of the internal space as well as on the wellbeing of building occupants have been recently published in the work of specialists, including Oberfeld and Hecht (2011), who analysed the impact of light and colours on users´ perception in internal environments.

However, the reintroduction of daylight and natural ventilation in the office buildings entails the redefinition of the conventional building form, distribution of the internal spaces, inclusion of transitional spaces and treatment of the facades. Such redefinition of the building model is associated with the challenge of the economic formula that determines the massive production of the conventional office buildings, characterized by the following market goals: the biggest usable area for the total built area, the minimum envelop area to the maximum floor area and the hermetic and uniform glass facade.

The benefits of daylight and natural ventilation to the wellbeing, sense of comfort and productivity of the occupants of office buildings have been widely and deeply studied and disseminated since the beginning of the 21st century. To deal with the challenge of urban noise, facade components combining openings and cavities for the incoming air with noise absorption can be used, as well as the so-called "chicanes" and double skin facades are useful design strategies for the reintroduction of natural ventilation in office buildings (CHILTON et al, 2012, ARAÚJO and BISTAFA, 2012). Some of the well-known factors that increased productive, and their amount, in workspaces are: between 6 and 9 per cent due to the internal air quality (WYON, 2004); between 3 and 18 per cent due to natural ventilation (NSF, IUCRC, 2004), between 3,5 and 37 per cent due to the localized control of thermal conditions and between 3 and 40 per cent as a factor of the daylight in the space (LOFTNESS et al., 2003).

Among many others, as already mentioned, two international icons of the generation of office buildings, in which the design concept was based on the benefits of more natural environments and on a critical approach to the deep plan office building and curtain wall are the Headquarters of the Commerzbank, from 1998, in Frankfurt am Main, in Germany, and the one originally designed to be the Headquarters of the Swiss Re, named 30 St Mary Axe, from 2004, built in the centre of London, both with the architectural design by the British architectural practice Foster and Partners. The daylight and natural ventilation strategies of the Commerzbank were elaborated by the same engineering practice that developed the initial environmental analysis of the 30 St Mary Axe, BDSP Partnership, based in London.

It is worth highlighting that the commercial building of better environmental performance and a differentiated architectural identity had an important predecessor: the Headquarters of the Hong Kong and Shanghai Bank, known as the HSBC, built in Hong Kong in 1986, designed by the same British architectural and engineering practices that design the Commerzbank Headquarters. The HSBC Headquarters is known worldwide for its central atrium with mirrors at the top controlled by a building management system that bring daylight to the centre of the floor plans. Besides the benefits of natural light, the atrium space allows visual communication across the several floors, valorising the vertical dimension of the interior.

In the Commerzbank building, the concept of the office village with a central atrium and terraces of quadruple floor-to-ceiling height, positioned around the triangular plan, facing each of the three orientations, constitutes the basic strategy for daylight and natural ventilation in the office spaces turned to the core of the building core, combining wind-controlled ventilation with stack effect (figure 4). Both at Commerzbank and the 30 St Mary Axe, the gains regarding the environmental and space quality have an impact on the conventional notion of space efficiency. In the Commerzbank, due to the area

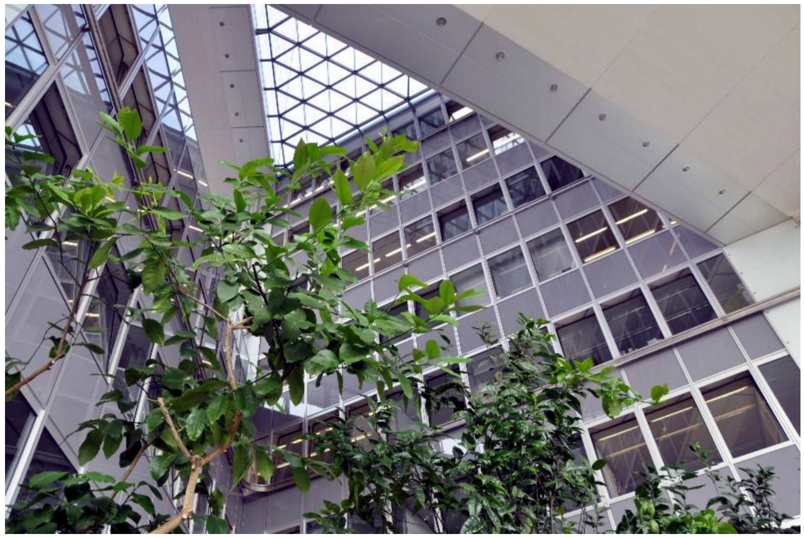

Figure 4: View of the interior of the Commerzbank building (1998), in Frankfurt am Main, Germany, showing the joint space created by the atrium and the 4 multi-storey gardens in one of the so-called office villages. Photo: Joana Carla Soares Gonçalves.

given to the terraces and the central atrium, only 35 per cent of the total built area of the tower is responsible for the traditional way of measuring the usable working-station area. However, even not being part of the conventional usable area, the terraces are effectively taken by the occupants as part of the working space, with intermediate microclimate conditions between interior and exterior.

As presented in Gonçalves (2015), the headquarters of the Commerzbank is naturally ventilated by 85 per cent of the occupancy hours, validating its iconic status as one of the best environmentally performative tall office building in the industrialized world and a reference for the use of natural ventilation in commercial tall buildings of similar bulk. A fieldwork in the Commerzbank HQ during a warm period showed that whilst the external temperature (measured by a weather station placed in the roof top of the tower) goes up to 29ºC in the middle of the afternoon, in terraces and atriums the air temperature does not exceed the mark of 26ºC. Furthermore, the studies revealed that Internal temperatures in three offices located at different heights of the same village, one at the bottom, another one at mid-height and the last one at the top, stay stable between 24ºC and 25ºC. These results are a consequence of the climatic mediation created by the terraces and atriums in the "office villages" and the maximization of natural ventilation in the core of the building.

Nevertheless, it is important to mention that the value of the environmental performance of the design of the Commerzbank headquarters goes beyond the numbers associated with the thermal conditions and energy efficiency. With an original architectural design of internal voids and multiple floor to ceiling heights, building systems made to the environmental performance of the architectural design and occupants prepared to a minimum dependency of artificial systems for cooling and illuminating the internal spaces, the occupied building re-establishes the culture of the natural ventilated office, with all natural temperature fluctuations, for a naturally ventilated space. At this point, it is important to say that the predisposition of the occupants of the Commerzbank to natural ventilation certainly contributes to the success of the strategy.

Figure 5: View from the ground floor of one of the spiralling perimetral atriums of the 30 St Mary Axe building. Photo: Érika Mitie Umakoshi.

In the design of the 30 St Mary Axe, a series of internal voids distributed around the periphery of the circular floor plan and a central core divide the tall building in a series of six-storey office villages. In this case, the double skin facade was designed to allow natural ventilation in all floors of the tower (figure 5).

Regarding the double skin facades, it should be said that this specific solution was originally developed in the decade of 1980 to office buildings in temperate and cold climates, promoting the maximization of the glass area to the penetration of daylight, without necessarily increasing the heat losses through the envelope. The composition of two glass panels and an enclosed cavity increases the thermal insulation of the envelope by approximately two times, reducing heat losses from the internal spaces to the exterior (PASQUAY, 2001). On the hand, in the warmer periods of the year (even in the cooler climates), the overheating of the glazed cavity led to the evolution of the double facade to the so-called ventilated double skin, for the removal of solar gains accumulated in the cavity exclusively, and not in the internal spaces. In the beginning of the year 2000, the ventilated double skin is then opened to the exterior and interior environments, facilitating natural ventilation in the internal spaces.

However, it should be clarified that the increased thermal insulation of the facade is not a requirement for the performance of the buildings´ facade in general and is definitely very risky in mild climates, such as in Sao Paulo and even Rio de Janeiro, even for buildings, which have totally artificially controlled environments. In fact, as demonstrated by Marcondes (2005), the double skin facade creates resistance to heat losses through the envelope during those hours when external temperatures are lower than the inner ones, as it happens during the night time period. In these cases, the adoption of external shading has a much more important role to the overall environmental performance of the building, blocking a great deal of solar gains.

Looking again to the design project of the 30 St Mary Axe, in this one, the architecture practice Foster and Partners brought back the idea of the *Climatroffice*, firstly developed in the 1970´s in collaboration with Buckminster

Fuller, which promotes the presence of vegetation into the working environment. The difference is that whilst in the proposal of the *Climatroffice* the working environment is still totally dependent on air conditioning systems, in the 30 St Mary Axe building, the vegetation is suggested in terraces juxtaposed to the spiralling atriums at the edge of the floor plan, associated with the natural ventilation strategy.

The technical assessment of the environmental performance of the building design, carried out during the initial phase of the design process, two scenarios of temperature set-points were tested, 24ºC and 26ºC, in two alternatives for the layout of the internal spaces, considering the cellular office and the open-plan typologies. As a result, for the specific case of the design of the 30 St Mary Axe, considering the set-point of 24ºC, the open-plan configuration showed the possibility of natural ventilation in 48 per cent of the occupied hours (GONÇALVES and BODE, 2015). Pushing the set point up to 26ºC led to a 66.2% increase in naturally ventilated hours. Keeping the limit of 26ºC, the cellular layout showed an even better performance, pointing out to the possibility of 76 per cent of the time.

Different from the case of the Commerzbank Headquarters, information available about the thermal and energy performance of the 30 St Mary Axe building, located in the heart of the city of London, are data from design and not from the actual occupied building, raising uncertainties about the real performance of the building. In summary, the critical analysis of both cases, the Commerzbank and the 30 St Mary Axe buildings, reveals that the natural ventilation in tall office buildings is not only technical viable, but adds authenticity and architecture expression to the project design.

Simultaneously, the 1990 was also a decade of the creation and wide dissemination of environmental certification, such as Leadership in Energy and Environmental Design, LEED, developed by the North-American Association U.S. Green Building Council, USGBC. At the same time that systems like this introduced a notion of environmental value to the design of buildings to the market (based mainly on energy related indicators rather than environmental quality), they also caused a wave of "*greenwash*" around the world, associated with the glass box typology in all climates, in other words, they justified the birth of a new generation of false references of "good practice" in environmental performance. Already in the first decade of 2000 (less than 10 years after its proposition), the effectiveness of the LEED certification, for example, was highly questioned.

In fact, Newsham, Mancini and Birt (2009) proved almost 10 years ago that 35 out of 100 North-American certified buildings were consuming more energy in their occupation routines than similar buildings, which were not designed to meet the checklist certification criteria. As them, many other post-occupancy evaluation practices proved the weakness of the so-called "green certification" of buildings. Applebaum (2011) published that a LEED certified building in North Caroline consumed more than the double of its neighbours built earlier and not certified.

As done by Buoro, Hernandes and Gonçalves (2015) a critical analysis of the assessment criteria of the LEED system, for example, reveals that the focus of these kind of green certification is much more on the energy performance of systems than on the characteristics of the architectural design, such as form, solar orientation, layout of the internal spaces, treatment of the facade and the design of window frames, which should be operable for possibility of selective natural ventilation. Together, these parametres have a fundamental impact on the final thermal response of the building to the local climatic conditions and, consequently, on the energy demand for space cooling as well as on the need for artificial lighting.

Looking at reality, how can a deep-plan building with a complete glass envelope (whatever the glass type), without any external shading protection, localized in a city of warm to hot climate, basically a solar collector under the sun and deprived from any daylight, since the glare coming from the glass facades is as much as the internal curtains must be closed most of the time, be certified as a good or excellent reference of environmental performance? Strangely, this is the building typology well qualified by green certifications in several cities in the world.

An effective manner of revealing the true environmental performance of buildings in general are the post-occupancy evaluation (POE) procedures, gathering information *in loco* about the occupants' satisfaction with their environmental conditions and the actual energy consumption by end use.

Besides the POEs, simple calculations of solar gains through the envelope can confirm the poor thermal response of glass buildings such as the ones cited above. As an example, Vieira (2015) identifies, by means of analytical studies the possibility to reduce up to 75 per cent the cooling demand in a typical office building in Rio de Janeiro (latitude 23º S), meaning the equivalent to 42 kWh/m^2 per year, versus 167 kWh/m^2 calculated for a typical conventional glass tower of rectangular shape and central core. The big reduction was due to the combined effect of external shading, night time cooling, internal exposed thermal mass and, finally, the rectangular form that facilitates the effectiveness of cross ventilation during the mild days of the year (approximately 1/3 of the annual occupied hours).

Design process and the role of analytical studies

Moving this critical reflexion back again to the innovative generation of office buildings initiated in the end of the 20th century, the environmental considerations and architectural solutions are articulated in a design process differentiated from the one of the sealed glass box, being the first one informed by analytical studies of advanced computer simulations to provide an in-depth assessment of the environmental performance of buildings, with all its complexity.

As widely discussed by specialists from the field and exemplified by Yannas (2008) in the article *Reconceiving the Built Environments of the Gulf Region, Challenging the Supremacy of Air Conditioning,* advanced analytical procedures are essential for understanding the complex energy balance of buildings and, consequently, of the architectural possibilities to the reduction of cooling loads, which means the buildings´ response to the relation between heat gains and heat losses throughout a day and in different times of the year (different seasons) and not only in extreme periods of a typical climatic year. Analyses such as this one, consider the form and orientation, building components and other aspects of the building design, besides information about use and occupational patterns.

Besides the recognized importance of shading strategies in the task of reducing solar gains, technical work conducted by Allard (1998) showed that the internal exposure of thermal mass could be reduced by up to 60 per cent the impact of heat gains in a conventional working space. As a result, it was verified that the combined effect of thermal mass and night time ventilation can offset up to 5ºC internal pick temperatures in a typical summer day, in a cellular naturally ventilated office building, in the London climate, in a possible future scenario of climate change for 2050.

Advancing the discussion about computer simulation of environmental assessment, Gonçalves and Bode (2015), in the publication *Edifício Ambiental (Environmental building),* presented in detailed the design process of the European practice, based on parametric-computer simulations of environmental assessment. The described process focuses the search for architectural proposals, which are specific to local environmental conditions, requirements of the building' function and occupants' expectations, therefore, creating a differentiation from the far simplified architectural approach to the environmental context, commonly seen throughout the second half of the 20th century, around the world. A clear and recent example of this environmentally responsive design is the office building named *One Airport Square,* in Accra (latitude 5° N), in Ghana.

In the design of the One Airport Square, OAS, with architecture from MCA - Mario Cucinella Architetto and environmental design as well as building systems from BDSP Partnership, thermal and daylight simulations were carried out to inform the dimensions of the continuous horizontal planes of the concrete shading devices, in which the depth varies according to the solar orientation and, consequently, to the amount of solar radiation incident on the

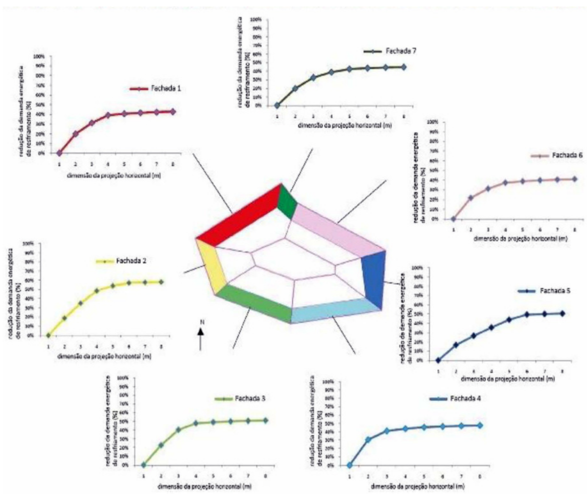

Figure 6: Parametric studies of computer simulation done for the design project of the One Airport Square building, which analyses the environmental performance of the horizontal shading devices at the 5th floor, based on cooling loads (kWhr/year). Source: Klaus Bode.

facade, with the objective of shading the glass facades without excessively and unnecessarily shading over the internal spaces, close to the edge of the floor plate (figure 6). As explained in Bode (2015), the simulation studies showed that, with the exception of the West orientation (O), where a horizontal shading device of up to 6 metres depth can still contribute to the reduction of solar gains, the effective contribution of the horizontal shading against excessive solar gains is restricted to the depth of 3 metres. Deeper than this, the efficiency of the shading element is minimum, besides the negative effect of making the internal spaces darker.

Given the depth of the plan, the spacious-shaded terraces that surround the floor plates were connected with a central atrium to create cross ventilation, improving thermal comfort in the OAS building, inserted in the warm and humid climate of Accra. The atrium was also conceived as an important device to bring daylight into the core of the building, however, it was important to shade it, to avoid excessive solar gains and glare to the offices located around the central atrium. As in the case of the external shading, parametric computer simulations were performed in this case to define the adequate glazing ratio of the roof of the atrium and the appropriate shading for the windows facing the atrium, on the higher floors.

Still regarding the introduction of computer simulation tools in design process, it is known that the most beneficial use of advanced environmental analytical assessments is in the early stages. When applied only in the final steps, after the architectural concept has been already frozen, the role of such tools and procedures is merely corrective, offering a marginal contribution to the environmental performance of the building. At the same time, the use of computer simulations for buildings´ environmental assessment, without the necessary knowledge of building physics, risks misinterpreting the results and, consequently, inappropriate design recommendations.

The influence of the office working culture

Shifting the discussion to the culture of the working environment and the consequent modifications of the standard model of the conventional office building of the second half of the past century, Frank Duffy, in his article *The Death and Life of The Urban Office* (DUFFY, 2007), published over a decade ago, explains that the changes in economics, policies and culture initiated in the decade of 1990, supported by the evolution of the Information-technology (IT), characterized the biggest transformation of the urban life since the Industrial Revolution. In the end of the decade of 2000, approximately 50 per cent of the global urban population was already engaged in some kind of office activity.

Duffy (2007) underlines the evolution of IT devices and resources coupled with the growth of the so-called *knowledge economy*, being this the productive activity that gives value to innovative and creative knowledge and ideas, introducing new occupancy and behavioural trends to the working environment, including more humanized spaces with vegetation, breakout spaces, visual communication between indoor and outdoor, plenty of daylight; in other words, working spaces that are literally greener, more opened to the outside, more flexible and inviting. Looking at this new reality, Duffy calls the attention to the role of architecture in legitimizing the needs and expectations of the contemporary society, as well as anticipating future spatial and environmental demands of the working place by presenting alternatives to the outdated model of the office building.

Having said that, assuming that the office of the future offers a *place*, an *environment* and not a *working station*, it is suggested here a definition for the working environment, in which a set of spaces encompassing balconies, gardens, terraces, atriums, are added to the internal spaces and become real potential spaces for several activities that constitute the new office. Following this proposal, architectural proposals are qualified by the diversity of environmental conditions (with more or less exposure to sun, light, air movement, temperature variations, noise and views). In this context, creative and collaborative work is encouraged as well as the contact with the outdoor climate, making the transition between indoors and outdoors, aiming for climatic mediation, visual communication and social interaction, as seen in the iconic buildings of a new generation presented here.

Regarding performance criteria, as in the case of adaptive thermal comfort models, in which, in simple terms, the comfortable conditions should vary according external temperatures, as it was presented by Nicol *et al* (2012) and incorporated in technical standards of thermal comfort: ASHRAE 55: 2013 (ASHRAE, 2013) and EN 15251:2007 (CEN, 2007), reasonably recent recommendations for the assessment of visual comfort propose a review of the narrow range of illuminance levels considered necessary in the working environment, such as the one adopted by the British institution CIBSE (2001), that vary between 300 lux and 500 lux only, to a much wider interval, applying the concept of Useful Daylight Illuminance Levels (UDI), in which acceptable illuminance levels can vary between 100 lux and 3.000 lux, according to Nabil and Mardaljevic (2006) and Mardaljevic *et al*. (2012). Other complementary research work, including the one developed by Reinhart (2012), establish a limiting difference between minimum and maximum values of 10 times in a space.

Following the evolution of the discussion about environmental comfort and the potential of building occupants to adapt to their environmental, Gonçalves and Bode (2011) defend the idea that the recognition of a wider flexibility in the definition of visual comfort favours a good use of daylight and visual communication between indoor and outdoor spaces, since a narrow performance band can rarely be achieved with daylight only, leading to the inevitable dependency of artificial lighting systems for almost the whole time of occupation, regardless of the climatic context. As explained earlier, the same analogy can be made for the case of thermal comfort criteria.

One is seeing here a call for a less monolithic architecture, with more spatial and environmental variety, to respond to the various needs and expectations of different occupants of a same space or building. The consequence of such an approach to the internal climate of the building is a more heterogeneous distribution of people and activities and of the associated production of internal heat gains. The understanding of the dynamics of occupational patterns and of the resulting internal thermic environment of the new office, the new workplace, has even a bigger impact on the environmental performance of the building, in the future of climate change and global warming, with major consequences to the energy demand in terms of space cooling.

With this concern in mind, the building complex Centre Buildings Redevelopment (CBR), from the London School of Economics and Political Science (LSE), with the architecture from Rogers Stirk and Harbour and environmental consultancy from Chapmanbdsp, concluded in 2019, is a recent and unique example of totally naturally ventilated working environments, designed to perform in the future of climate change. The architectural project is based on principles and features of environmental design, aiming to benefit from daylight and natural ventilation, with a narrow plan (maximum 12 metres deep), openings on opposite facades, external shading devices, internally exposed thermal mass, coupled with transitional spaces and control mechanisms for the occupants to adjust their environmental conditions. Exploring the design opportunities beyond the principles of building physics, parametric computer simulations were used for the sizing of solar protection and windows' openings, considering the London climate today and in 2050 (BODE, 2019).

The CBR building complex, which was the outcome of an international architectural competition, was conceived and detailed to be entirely naturally ventilated during all occupied hours, all year round, without the provision of any kind of air cooling system. In other words, this is the true naturally ventilated building of its time, dedicated to working spaces. The audacious proposal of an iconic building of such a prestigious international institution, without the existence of a cooling system, certainly has a fundamental impact to the reaffirmation of natural ventilation as a possible means in the contemporary architecture of working environments. According to the engineer Klaus Bode (BODE, 2019), the decision of not including any kind of air cooling system is related to the fact that when available, even if only for extreme situations, these systems are often switched, even when not necessary. For this reason, the biggest challenge of the design was to eliminate any risk of overheating in the working spaces, in the current and future climatic conditions, using only architectural features.

Whilst a number of existing buildings built to be naturally ventilated (such as MEC in Rio de Janeiro), undergo major refurbishments to be artificially conditioned for the whole occupational time, responding to cultural values that go beyond a real climatic demand, initiatives for natural ventilation in working environments in major urban centres of the global economy are beginning to appear in the international context, looking at the challenging climatic future of urban centres, with the forecast of global warming due to climate change. To achieve such an objective in the design project of the CBR building, a vision that believed in the investment of a building proposal inserted and adapted to the conditions of the local climate was applied. The design project reengaged basic principles of building physics, which were then explored by means of analytical processes of environmental assessment, carried out with the use of parametric computer simulation tools. This is an example of technology deployed in the design process to remove technological devices from the use and operation of the building.

In this project, the shading devices were sized precisely according to the computational calculation of solar radiation incident on the facade, considering the obstruction caused by the neighbouring listed buildings. For this reason, the external vertical fins are wider at the higher floors than at the lower ones. Among a series of environmental strategies elaborated for the performance of the building complex of the CBR, modifications of the internal layout consider reductions in the occupancy density and open plans offices (landscape) with the possibility of cross ventilation, to provide the internal spaces with comfort conditions during the warm periods of the year in the future of climate change relying only on natural ventilation and keeping the building independent from air conditioning systems, such modifications were determined at the initial design stage when overheating was identified in some specific spaces, in the scenario of climate change for 2050.

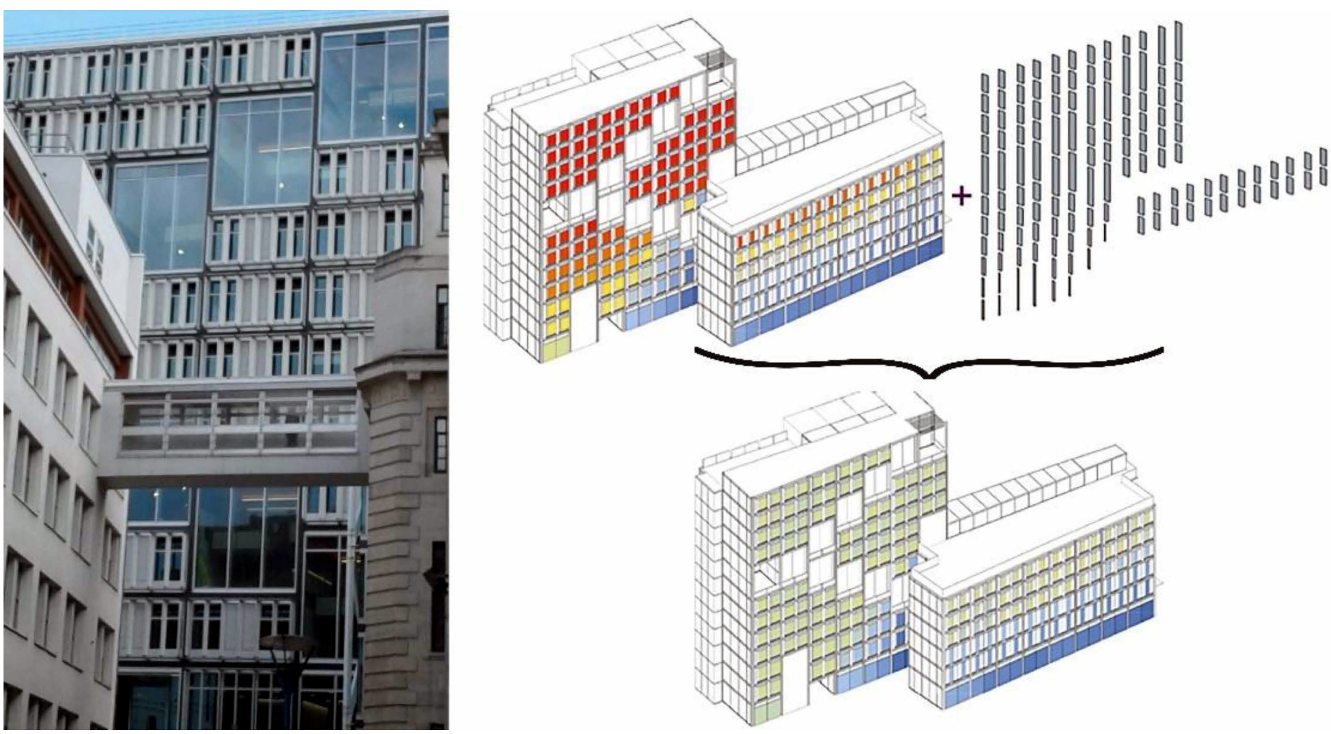

Figure 7: The main facade of the CBR building, from the London School of Economics (2019), highlighting the analytical design process (at the top) and external view characterized by the predominant presence of the vertical fins in the final architectural composition of the facade. Photo: Author, drawing, Klaus Bode.

Final considerations

In summary, three spatial and environmental design strategies qualify the internal environment for the creative work, social interaction and productivity. These are: *integration between interior and exterior*, mainly by the maximization of passive strategies for the achievement of comfortable conditions, in particular daylight that improves the perception of space quality as well as occupants wellbeing and productivity, and the energy conservation associated with the use of air conditioning systems and artificial lighting; *spatial diversity and environmental quality,* which offers to the occupants, by means of adaptive strategies, the option to change the internal environmental conditions to achieve more or less daylight, sun, privacy and exposure to noise as well as a different place in the space for the individual carry out his or her activities in a specific moment in time; and *flexibility of internal configuration,* by means of which the arrangements of internal spaces are modified to accommodate other purposes or even to improve the environmental conditions.

Different from what prevails in the more conservative design practice in the global context, examples of a generation of more environmentally driven buildings, which has been evolving in terms of form, configuration of internal spaces and treatment of the envelope since the beginning of the 20th century, such as in the case of the CBR building in London, are design projects conceived for more tolerance and adaptation of environmental variable, as opposed to total artificial control of the internal environment. These concepts, followed by a parametric-analytical process of evolution/development of the project are, certainly, the most suitable way to the future of architectural projects truly geared to minimize the environmental impact of the built environment.

Concluding with the words of Duffy (2007, p. 338): *"The principal task of urban designers and architects is to imagine and legitimize diversity and to convey to clients, politicians and the general public a sense of the richness of choice that the freedoms provided by information technology can bring to society in the knowledge economy. The worse thing we can do is to attempt to force the new economy into buildings designed to reinforce outmoded ideologies. How wide is the range of possible alternative urban and architectural forms we can anticipate? The potential range is enormous – diversity is everything."*

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