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Better Public Spaces: Developing Environmental Guidelines for the City of London

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Gwyn Richards is the current Interim Chief Planning Officer and Development Director at the City of London. He has worked in the City for over 10 years as Head of Design and at the Principal Officer level. Prior to this, he worked at the Senior Officer level at Westminster City Council and the Royal Borough of Kensington and Chelsea. He oversees negotiations on the tall buildings and major developments in the City, as well as strategic initiatives such as 3-Dimensional and Growth Capacity modeling, as well as re-imagining public space on the roofs and upper stories of major developments. He also leads the City's award-winning microclimatic modeling, to better understand the City's cluster of tall buildings and their microclimatic impacts on wind, sunlight to ground, and air pollution, as well as the ground-breaking Thermal Comfort modeling.

Abstract

The City of London is expected to see a significant growth in the number of tall buildings in the next decade, with several tall buildings nearing completion and many more in the planning and construction pipeline. These buildings inevitably have some impact on their environment, which can be challenging to resolve, particularly in the context of the narrow medieval streets criss-crossing the City. To address this challenge, the City planning team decided to embrace advanced modeling tools to carry out detailed evaluations of wind microclimate, overshadowing, air quality and thermal comfort conditions across the entire City. This paper provides a summary of the approach and outcomes of these environmental studies, which have culminated in the development of UK's first guideline on wind microclimate studies, and a new thermal comfort guideline to be published in Summer 2020.

Keywords: Microclimate, Pedestrian Safety, Public Space, Thermal Comfort

Introduction

Growing urban populations require additional infrastructure, which, in already densely populated areas, frequently means taller buildings. In London alone, more than 200 tall building projects have been built or initiated construction in the past 10 years (CTBUH Skyscraper Center 2020). Although the benefits of such structures are many, they can have detrimental environmental impacts on their surroundings, such as altering wind patterns in the area, reflecting or limiting sunlight, and other undesirable changes to the environment. This paper provides a summary of a holistic study to address such environmental challenges in the City of London context, with the aim of improving the health and well-being of cities worldwide.

Environmental Challenges

Also known as the Square Mile, the City of London on the north bank of the River Thames has been a leading global financial center for centuries. With a tapestry of medieval passageways and streets, the City did not feature many tall buildings until the 1980s, when planners set aside an area known as the Eastern Cluster for the development of tall towers to meet the growing need for office space in the borough. Since then, the Eastern Cluster has become home to a number of skyscrapers synonymous with the financial prowess of London, with many others either approved or under construction (see Figure 1).

However, placing modern high-rise towers within the narrow streets of the City is not an easy task; the challenging site constraints often dictate a sophisticated approach to design, and can limit the amount of public spaces that can be created at ground level. Tall buildings can also have severe impacts on their surroundings, as demonstrated by one particular building soon after its completion, a 36-story high-rise at 20 Fenchurch Street, also known as "the Walkie-Talkie." Located on the edge of the Eastern Cluster, this structure resulted in unexpected and quite dramatic wind and solar effects on the local area soon after construction. This led City planners to seek insight into the potential effects of other proposed structures, to avoid this type of adverse effect from future development.

As the City is growing, it is also undergoing a cultural shift. Traditionally, this part of London has been filled with historic buildings that for centuries served as the trading center of London, with guild halls, coin exchangers, and the like. Now, however, the demographic of a typical City dweller continues to change, as the City becomes home to a wider array of modern firms, with users demanding high-quality public spaces. Added to this is the growing scientific evidence indicating significant health and well-being benefits of high-quality outdoor public spaces (Korpela et al. 2014). Like many other cities around the world, the quality and value of public spaces is a paramount consideration for City planners.

Improving the Knowledge Base

All tall buildings in the City require a planning application, which is accompanied by various environmental assessments, including wind microclimate, sunlight/daylight yields, and air quality. These environmental effects are traditionally captured in separate chapters of a planning application, often conducted by different consulting firms, limiting the ability of the planners to evaluate the combined impacts of different environmental factors. Also, there were no established technical guidelines on how some assessments, such as wind microclimate, should be carried out in London, even though these types of studies have been carried out to support planning applications for decades.

With the advanced modeling and analytical tools available to the design community today, it is now possible to predict and account for numerous environmental effects of a new building at the same time. But even more importantly, designers now can go beyond considering individual structures, to consider the collective effect of a group of buildings on the microclimate, which may yield quite different insights than solely considering the effects of individual buildings. Such higher-level modeling and analysis enable the consideration of many more "what-if" scenarios, allowing designers and planners to optimize both urban planning and building design.

Wind Microclimate

The first phase of the study focused on the effects of wind microclimate on pedestrian comfort. There are primarily two types of tools used in the industry for assessing wind microclimate; namely, wind tunnel testing and computational fluid dynamics (CFD). Within these two categories, there are further variations in the types of testing and CFD methodologies used by different consultants. This lack of consistency created challenges in the way such studies were being conducted and interpreted.

Figure 1. Eastern Cluster of skyscrapers in the City of London. © James Burns, City of London

Figure 2. A comparison of wind comfort conditions around the Eastern Cluster, as obtained from CFD simulations (continuous color contours) and wind tunnel tests (discrete color-coded dots). © RWDI

> “A key feature of the new London microclimate guidelines is the requirement to use both CFD and wind tunnel methods, carried out by independent consultants.”

Initially, a comparative study was carried out using detailed wind tunnel tests for the Eastern Cluster and a commonly-used and economical CFD method called Reynolds Averaged Navier Stokes (RANS). In Figure 2, the color contours represent the results of RANS simulations, while the color-coded dots indicate the results from wind tunnel sensors. While RANS models provide information everywhere throughout the model, such models are not as precise in simulating gusts of wind as the large eddy simulation (LES) method or wind tunnel testing (Blocken 2015). On the other hand, wind tunnel tests are limited in the number and positioning of sensors that can be placed around a site, with some variability in the equipment and experience of different wind tunnel users. It is clear that combining CFD and wind tunnel testing provides a far more comprehensive picture of the wind microclimate than could be achieved by using one tool on its own. In fact, for a tall building, it is ideal to initially use CFD methods to gain an understanding of key flow features, validate the CFD results against early-stage wind tunnel tests to confirm gust effects, and then use CFD or wind tunnel testing to optimize the building geometry. Using the two tools together also allows the optimization of wind mitigation measures, which ultimately reduces costs and unattractive additions to buildings.

But the choice of method used for the study is not the only parameter affecting the quality and consistency of wind microclimate studies. In fact, there are a number of other factors that could lead to much larger uncertainties in results, compared to typical differences between wind tunnel and CFD studies, including the following;

- Wind climate statistics (directionality, probabilistic distribution of wind speeds);
- Number and selection of wind directions simulated;
- Oncoming boundary-layer wind profiles (both mean and gust), and the uniformity of these profiles across test areas;
- Extent and detail of surrounding buildings;
- Level of surface detail incorporated into the proposed building(s);

- Local ground-level obstructions, e.g., landscape features and public furniture;
- The type of CFD method (RANS, URANS, LES), the mesh density and turbulence modeling techniques;
- Wind tunnel model accuracy, probe density and instrumentation quality.

It is clear that having consistency in some of these input parameters can greatly reduce the variability of uncertainties in wind microclimate studies. For example, Figure 3 compares the wind comfort conditions across the Eastern Cluster for several scenarios, firstly using a CFD study with a different number of wind angles included, and secondly using a wind tunnel test with long-term weather statistics from different airports around London. As can be seen, the selection of weather data also makes a big difference to wind simulation results. The number of wind directions is seen to have a lesser effect for the geometry of the buildings shown here, but for some buildings with very sharp corners, the number and selection of wind directions can significantly change the location and magnitude of wind accelerations around the corners.

The Wind Microclimate Guidelines

The second phase of the study involved the development of the UK's first-ever wind microclimate guidelines. Two workshops were conducted with key firms in the industry—including AECOM, Arup, BMT, BuroHappold, BRE, RWDI, Wirth Research and WSP—to solicit input on methodologies and technical parameters. The resulting guidelines, published in August 2019 (City of London 2019) provide a consistent set of weather statistics, require the simulation of 36 wind directions, stipulate the level of detail required in CFD and wind tunnel models, and set out a coherent approach for presentation of results. A key feature of the new guidelines is the requirement to use both CFD and wind tunnel methods—to be carried out by independent consultants—for a comprehensive understanding of wind microclimate around tall buildings (see Figure 4). The guidelines also include more

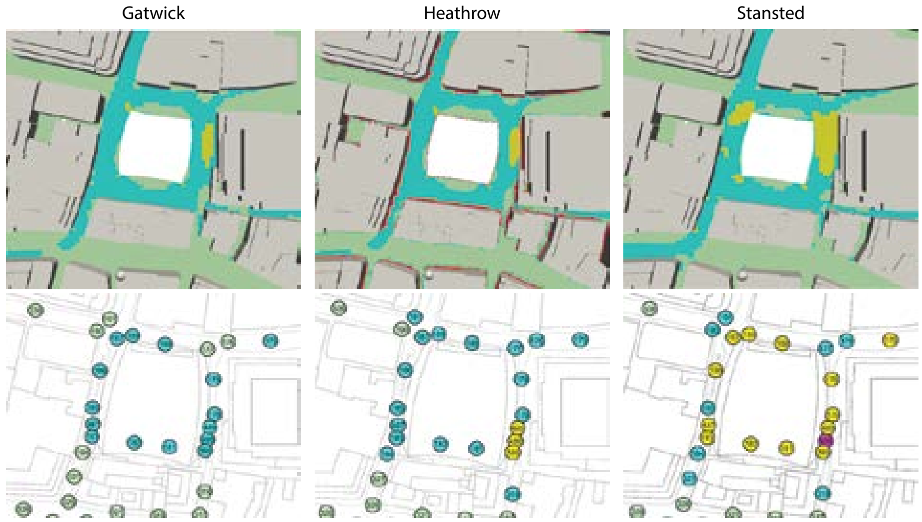

Figure 3. Wind comfort conditions at the intersection of Bishopsgate and Leadenhall Street with (a) different number of wind angles and (b) different wind climate statistics. © RWDI

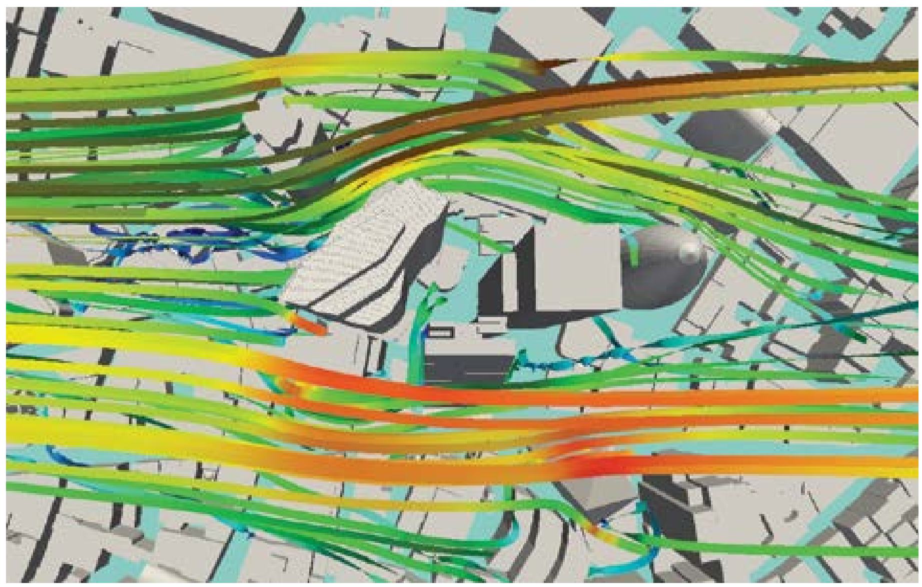


Figure 4. Flow visualization showing the so-called "huddled penguin effect" that is created by the collective impact of all tall buildings (top). The City of London model at RWDI's wind tunnel (bottom). Both types of models are now used to substantiate the City's microclimate guidelines. © RWDI

stringent comfort criteria and a review of wind effects on cyclists for the first time in the UK. It is noted that the guidelines can be easily adapted to other locations, and it is hoped that other cities worldwide will adopt similar approaches to wind microclimate studies.

Overshadowing and Thermal Comfort

While wind is one of the primary factors influencing outdoor comfort in colder northern European climates, it is not the only factor. In fact, sunlight, noise, air quality, visual aesthetics and many other subjective factors also play a part in the quality of the outdoor amenity. To enrich the planners' ability to review outdoor comfort more holistically, phases 3 and 4 of the study focused on solar and thermal comfort aspects, respectively.

The solar study provided an understanding of the overshadowing effects of tall buildings. As one would expect, some parts of the City enjoy ample sunshine, while parts of the Eastern Cluster receive almost no sun at all. Using a detailed solar study, one could also determine the maximum allowable height before a building on a given site would result in loss of light for the residential dwellings in its vicinity, which helps define possible growth scenarios for the City.

Figure 5. UTCI comfort conditions in the Square Mile during summer (top) and winter at midday (bottom). © RWDI

The results of the solar study were then combined with wind microclimate conditions and ambient climate parameters such as temperature and humidity. This is often referred to as a "thermal comfort simulation" and provides a more comprehensive understanding of outdoor comfort, compared to studies that focus on one environmental parameter at a time. There are several different thermal comfort criteria with varying degrees of complexity. The Universal Thermal Climate Index (UTCI)—developed by the European Cooperation in Science and Technology (COST) 730—had the goal of creating a thermal comfort metric that could be applied in a wide range of climate scenarios (Fiala, Dusan et al. 2012). This metric was selected for the guidelines due to its open-source nature and computational efficiency, and because it does not require additional inputs for an individual's clothing and activity level. While these simplifications are not always desirable, for a temperate climate like London they are reasonable, and also enhance the consistency of the methodology, which is important for planning. Figure 5 shows the thermal comfort ranges of UTCI, and the predicted midday thermal comfort conditions in the City during summer and winter seasons.

Close inspection of the thermal comfort ranges and discussions with the City of London planning team members—who are familiar with the comfort and popularity of various locations across their borough—highlighted several surprising results. For example, some of the well-known areas around St Paul's Cathedral and Finsbury Circus Gardens have "moderate heat stress" conditions during summer when using the standard UTCI classification, but City planners considered these to be some of the most sought-after areas during warmer months. Similarly, many parts of the Eastern Cluster are observed to be in the "slight cold stress" category during winter when using the standard UTCI categorization, even though City dwellers continue to utilize public spaces frequently on calm, sunny days in these months. Another issue raised by the City planners was the lack of

Figure 6. Contour plot showing the thermal comfort conditions, using the modified UTCI categorization developed for the City of London. © RWDI

Category	Percent of Hours with Acceptable UTCI	Description	Color
All Season Sedentary	≥90% in each season	Appropriate for sitting uses year-round *(e.g., parks)*	Green
Seasonal Sedentary	≥90% spring-autumn AND ≥70% winter	Appropriate for sitting uses during most of the year *(e.g., temporary outdoor dining)*	Purple
Short-Term Sedentary	≥70% in all seasons	Appropriate for short duration and/or infrequent sedentary use *(e.g., bus stops, entrances)*	Cyan
Transient	≥70% spring-autumn AND ≥50% winter	Appropriate for public spaces where people are not expected to linger *(e.g., pavements, cycle paths)*	Orange
Thermally Uncomfortable	<50% in winter OR <70% in any other seasons	Not appropriate for regular comfortable pedestrian use without mitigation	Red

Table 1. Thermal Comfort Guidelines developed for the City of London through the authors' research. © RWDI

granularity in the UTCI results. Average conditions are generally the same for large swaths of the City, which does not provide the ability for planners to evaluate comfort variations on a more local level. These observations suggested the need to use a different comfort classification approach for the specific requirements in London.

For planning purposes, it is the change in thermal comfort caused by a proposed building which is important to quantify, which requires a more granular use of the UTCI criteria. Several studies (Reinhart et al. 2017, Binari 2020) have shown that the standard UTCI categorization of no thermal stress can be overly strict, even in temperate climates. As such, based on a review of the meteorological data and review with planners and locals, a UTCI range of 0 to 32°C was found to provide reasonable descriptions of which spaces were considered attractive. Spaces are then classified based on the frequency of occurrence within the target range. Figure 6 shows the comfort categorization developed for the City that not only provides a more granular description of thermal comfort conditions, but is more in-line with the expectations of City planning team members who were familiar with general comfort conditions in parts of their borough. The criteria used for the classification—color-coded to be suitable for people with most types of color vision problems—uses the percent of time that the conditions are in the UTCI range of 0–32°C as a descriptor of comfort, as summarized in Table 1. As would be expected, windy and/or shady areas tend to have lower comfort ratings, while sheltered, sunny spots have the best comfort conditions. Comparing the classifications of pedestrian spaces with and without the proposed building allows for easy identification of spaces where thermal comfort is negatively (or positively) affected by the building.

Currently the project team is using the modified comfort classification approach during the development of new Thermal

> “Some of the most sought-after areas of public space in the City were classified as being subject to ‘stress’ conditions under standard climatic classifications, outlining the need for a specialized approach.”

Comfort Guidelines for the City, in consultation with an array of international engineering firms (AECOM, Chris Twinn Sustainability, Hilson Moran, Ramboll, Thornton Tomasetti, Wirth Research and WSP). When launched in summer of 2020, these were to become the UK's first planning guidelines focusing on the comfort of pedestrians in external spaces, providing a platform for the City to safeguard the quality of its public spaces. It is noted that this first edition of the Thermal Comfort Guidelines was aimed at raising increased awareness of thermal comfort in a planning context, and allowing a wider range of consultancies to develop tools for this type of study. Therefore, the guidelines intentionally utilize simplifications, including the use of "typical" meteorological year files as an input, simplified mean radiant temperature calculations that ignore specular reflections, thermal mass and radiant effects, and omission of urban heat island or climate change variabilities. However, the current approach still provides useful feedback to planners by focusing the analysis on evaluating the aspects of a building that are better-defined at the early planning stage (i.e., massing) as opposed to aspects which are often less developed (e.g., materiality and landscaping). It is expected that future versions of the Thermal Comfort Guidelines will include a wider array of simulated physics, and potentially modifications to the categorization of spaces informed by scientific literature and user surveys within the borough.

Advances in Climate Modeling

The project team is continuing to expand the assessment of environmental effects in the City by focusing on other parameters that affect the health and well-being of users. A computational air-quality study for the Eastern Cluster is currently underway—conducted in collaboration with University of Southampton, the study leverages high-performance computing to understand the impact of tall buildings on traffic-generated pollution. As tall buildings can significantly change the wind flows in their vicinity, it is expected that they will have an influence on the distribution and concentration of pollutants in urban street canyons.

In the longer term, the team is aiming to holistically assess climate change impacts, heat island effects and other environmental factors (e.g., noise) in future phases of the project. Other advancements could also include utilizing open-source tools such as Geographic Information Systems (GIS) and/or open-source gaming technology to freely share the output of such studies with the public, to facilitate further research and collaboration on this important topic.

Concluding Remarks

The City of London embodies the typical characteristics of a major city center, with crowded, narrow streets, a tapestry of important and historic buildings, and a continued need for new high-rise office towers. The combination of these factors demands a high-quality approach to the design of tall buildings, particularly in the evaluation of environmental effects, which can be significant.

In this project, advanced modeling tools were used to investigate the environmental impacts of tall buildings, with the aim of allowing City planners to proactively plan for future changes in the City's skyline. In parallel, robust guidelines have been and continue to be developed, providing consistent, high-quality environmental assessments. The technology is reaching a point where environmental disciplines no longer need to be handled separately from each other, and a holistic approach to design is possible and desirable. The combined influence of these initiatives allows the City planning team to safeguard the quality of external public spaces in the borough, which continues to be critically important for the amenity and well-being of City dwellers. The knowledge gained through this study can be applied to other major city centers in the world, particularly to provide robust guidelines for environmental assessments, and digital modeling tools to evaluate the impact of large developments. ■

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