"Green Pockets" as Microclimate Modifiers in UK Urban Schools

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"Green Pockets"
as Microclimate Modifiers in UK Urban Schools

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ABSTRACT: The rapid densification of many UK cities poses significant pressure on the design of schools within inner city centres. London's air quality has been associated to increased mortality, and pollution and noise levels have exceeded acceptable standards. As a consequence, most schools are mechanically ventilated and have little or no contact with the outdoors, with detrimental effects for the physical and mental development of students (Charles, 2015). This study investigates the possibility of improving the design of usually neglected and underexploited outdoor and semi-outdoor spaces within urban learning environments in order to convert these spaces into microclimatic modifiers and natural air filters. The research focused on the integration of green spaces into three different environments: outdoor courtyard, semi-outdoor break-out space and indoor classroom. The findings of the analysis and design implementations indicate that the positive microclimatic effect of the green courtyard can be successfully used to achieve thermal comfort in semi-outdoor and indoor spaces throughout the year while improving visual comfort and air quality.
KEYWORDS: green school, pollution, vegetation, guideline, urban schools

1. INTRODUCTION
1.1 Research Topic

This research presents an innovative inverted architectural design approach based on the negative "pockets" created by UHI, where the outdoor becomes an informing factor of the design. This is achieved by the implementation of "green pockets" - spaces of a different architectural scale and purpose with a direct access to vegetation. The research is a theoretical exploration of design possibilities based on the actual case study of Architype initial project proposal for one of the secondary schools in the strict London city canter.

1.2 Methodology

The "green pockets" strategy provides the analytical study of three scales of intervention: courtyard, breakout and classroom (Fig.1). For the purposed of this paper the objectives of air pollution and visual comfort are omitted to present how the connection between them affects thermal comfort and energy consumption.

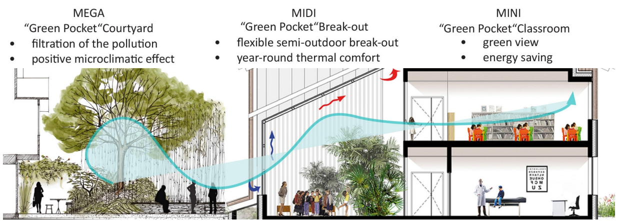


Figure 1: Green Courtyard Concept Section

2. CONTEXT

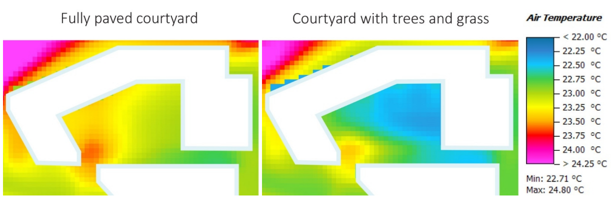
According to ASHREA, thermal comfort in London can be only achieved before early afternoon from June to August. Considering that school children spend a majority of their daytime hours at schools, this brings a new obligation to educational facilities to provide them with a sufficient contact with the outdoor environment.

Nevertheless, such endeavour has many constrains that needs to be considered based on the literature review and case studies research. The pollution levels in London in January 2017 peaked at 197μg/m³ for PPM (Knapton, 2017), exceeding the benchmark of 70μg/m³ for developing cities. Noise level in proximity of busy roads can easily reach 80 dB surpassing 60 dB allowed for learning. This and many other densification factors currently leads to design of schools as "sealed mechanically ventilated boxes", while they could be mitigated by conscious use of geometry and vegetation.

3. ANALITIC WORK
3.1 MEGA "Green Pocket" Courtyard

In the first stage of the macro scale, the "Green Pocket" Courtyard is proposed, with an objective to provide a secure outdoor space for students, which would work as an air-filter and temperature-regulator.

Firstly, the research explore the changes of the air temperature and thermal comfort due to different greenery arrangements (Fig.2).



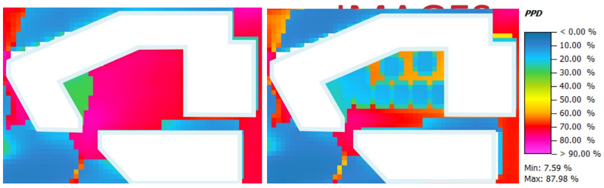


Figure 2: Microclimatic effect of different types of greenery on an average summer day (created with Envi-met)

The second type of the simulation combines the effect of the geometry with the most successful scenario of fully green courtyard and compare its thermal conditions to the adjacent temperatures of the site. This way the temperature change profile is created that is used in the further stages of the research (Fig.3).

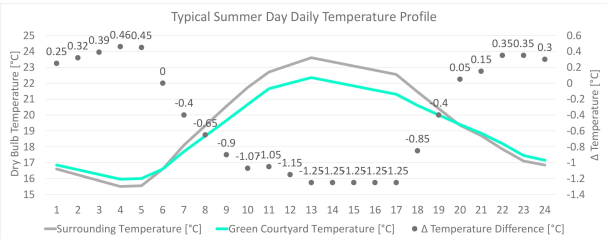


Figure 3: Positive microclimatic effect of the courtyard – average summer day (Meteonorm + Envi-met)

The observation of the changing condition in the courtyard indicated that the positive microclimatic effect of the sheltered courtyard is noticeable during the entire year. In summer the courtyard with trees and grass benefits from higher temperature mitigation and lowest PPD ratings. However during the colder months of mid and winter season trees obstruct till some extend the desirable solar radiation, thus affecting and mrt temperatures and decreasing thermal comfort.

3.2 MIDI "Green Pocket" Break-Out

In the second stage of midi scale the "Green Pocket" Break-Out space is proposed. The temperature change profile achieved by implementing the green courtyard is used in dynamic thermal modelling in TAS to create a flexible semi-outdoor space that could be providing an outdoor-like experience with a whole year-round thermal comfort conditions, which was proven to be of a critical value for outdoor learning opportunities in climate like London.

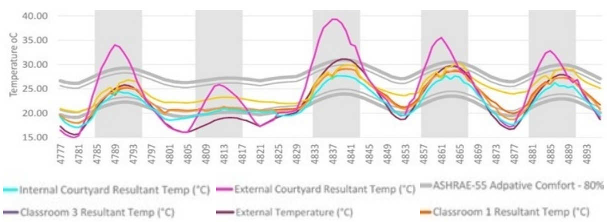


Figure 4: Final case scenario resultant temperatures (TAS)`

The dynamic thermal simulation studies on the base case geometry proved that with integrated utilization of outdoor courtyard temperatures mitigation it is possible to achieve the semi-outdoor flexible space that would be thermally comfortable through the whole year and during extreme weather events (Fig.4).

3.3 MINI "Green Pocket" Classroom

In the third stage of micro scale the "Green Pocket" Classroom is considered. The main objective of this stage is to understand the possibility for natural ventilation of the classroom using the environment from two previous stages providing a whole-year round thermally comfortable classroom environments with enhanced visual comfort and air quality.

The cooling and heating loads of the basic case and the final case were compared in order to understand the potential savings achieved by introducing natural ventilation, small architectural interventions (like shading and buffer zone) and mitigated effect of green courtyard. The final proposal achieved the yearly load of 16 kW/m^2 for heating and cooling – only slightly above the passive house standard (15 kW/m^2). This value is over 3 times lower than the standard for UK of 51 kW/m2 for electrical heating with natural ventilation in secondary schools (CIBSE, 2008).

4. CONCLUSION

The "Green Pocket" Concept proved to work according to the assumptions by proving a year-round thermally comfortable indoor spaces and reducing the energy consumption. The integrated approach resulted in lower daytime temperatures, and slightly higher night time temperatures in the courtyard as well as indoor areas of comfortable resultant temperatures and only 16 kWh/m2 of heating and cooling loads per year.

The methodology and findings of this study aim to help the designers to take better-informed design decisions in response to current challenges that UK's urban schools are facing.

LIMITATIONS

As the research is based on an particular project case study it does not investigate various dimensions of the pockets which could be further investigated.

ACKNOWLEDGEMENTS

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