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Hacking the Street _ Regenerative Design Principles for the Existing Urban Street Section and Public Realm

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Abstract: According to the UN, two out of every three people on the planet will live in cities by 2050 (UN-DESA, 2019). For sustainable development, cities must dynamically control and restrict their growth, save biodiversity and ecosystems, and at the same time address housing needs. Cities must simultaneously lessen their influence on the microclimate and increase their resistance to climate change. Brownfield site infill and urban regeneration, which revitalise the neighbourhood and environment, are one solution.

The design project incorporates regenerative techniques and natural components into the existing street section of Wallis Road in London, UK, a former industrial site, based on environmental studies, working with the terrain through measures of soil bioremediation and flood resilience.

The developed prototype is a sustainable addition that adapts to the local environment and enhances the microclimate of the neighbourhood, pedestrian comfort, and ecological regeneration while reducing the effects of climate change on the urban population.

Keywords: Regenerative Design, Urban Microclimate, Pedestrian Comfort, Flood Resilience, Bioremediation

1. Introduction

The UN-Habitat 2020 New Urban Agenda handbook highlights that besides the urban population increase, cities are expanding faster than their population, with a growth rate of 1.8 for urban extent vs. 1.2 for its populations (UN-Habitat, 2020). Cities must adapt to dynamic growth management by limiting urban sprawl and utilising urban regeneration while at the same time conserving and protecting ecosystems and biodiversity, calling attention to the introduction of natural elements into the built environment. According to the UN-Habitat World Cities Report 2022, Nature-based solutions (NBS) are a potential mechanism to manage the impacts of climate change in urban spaces. NBSs aim to protect, sustainably manage, and restore (create) natural or modified ecosystems (UN-Habitat, 2022). Apart from the basic ecosystem services such as food, water, and cultural benefits, they support regenerative ecosystem services like nutrient recycling, soil conservation and microclimate regulation (UN-Habitat, 2022).

According to the latest IPCC report (2022) cities are considerably vulnerable to climate change and must find strategies to mitigate and adapt to the impact of climate change by becoming more resilient while reducing their own CO2 footprint. The report states, that *'Sustainable urban planning and infrastructure design including green roofs and facades, networks of parks and open spaces, management of urban forests and wetlands, urban agriculture, and water-sensitive design can deliver both mitigation and adaptation benefits in settlements. These options can also reduce flood risks, pressure on urban sewer systems, urban heat island effects, and can deliver health benefits from reduced air pollution.'* (IPCC, 2022)

The thesis project will explore, how the existing street section as an urban typology can be regenerated to become more resilient to and mitigate the effects of climate change.

2. Background

According to the Koeppen-Geiger climate classification, the thesis project site is located in a temperate, no dry season, warm summer (Cfb) climate zone and is geographically positioned at 51.543417°N, 0.024389°W, London, UK. London has predominant seasons throughout the year, with long mild winters and short summers.

Comparing the climate data for 2020 and 2050, it is estimated that in summer, more often peek temperatures of more the 30°C will be reached, with higher daily average solar radiation levels of more than 5kW/m² with a sunnier sky. The rainfall is also reduced in the 2050 scenario but increases during the winter and mid-season with a more partially or cloudy sky.

2.2 Urban Context

The Olympic Park is the key element of the London Olympic games (2012) and connects all venues. The site was used as former industrial land with heavily polluted grounds as well as the river Lea running across from north to south. The area spans over four London boroughs and was formerly one of the most deprived in East London.

The regeneration of the contaminated land was a large operation and took three years to complete, washing and replacing the soil on-site and adding a 500 mm nutritious topsoil layer for plants to thrive. With the Olympic Legacy, long-term benefits for the area have been created through regeneration of the site and reuse of the venues and buildings.

The thesis project site is located in the London borough of Hackney, East London, and within the boundaries of the London Legacy Development Corporation LLDC. With the Hackney Wick station, the quarter is connected to the London Overground network and is on either side, bordered by the Lee Navigation canal to the east and the A12 (major road) to the west. With large parts of the area being categorised as Flood Zone 3.

Wallis Road runs through the neighbourhood connecting the Queen Elizabeth Olympic Park (east) and Victoria Park (west) via footbridges over the canal and major road. The area is currently undergoing redevelopment from industrial to residential use, with building works started in 2017 and still ongoing.

2.4 Remediation

Like the Olympic Park, the ground is heavily polluted due to the former industrial use of the land along the canal. Remediation measurements were part of the planning process; however, with the onset of the building works, complaints were received from residents about noxious smells and headaches from fumes coming from the excavation works.

Hackney Wick sites were treated individually and in a dense urban setting. The ground is contaminated with Hydrocarbons which are known carcinogens, with high-risk levels of Naphthalene, volatile organic compounds and an elevated concentration of Arsenic and Lead within a depth of 3-4m, resulting in commonly sealed grounds or soil being cart-away when redeveloped.

New techniques like bioremediation and the use of fungi to degrade pollutants in soils are being researched and could be a solution for these sites and be part of a systematic regenerative approach. Common pollutants like PAHs (Polycyclic Aromatic Hydrocarbons), which occur naturally in crude oil, coal, and gas, are hydrophobic and do not break down easily and are resistant to microbial degradation due to their low water solubility. Bacteria can degrade PAHs as well as, Ligninolytic fungi (White root fungi). Mycoremediation utilises the fungi mycelium, the vegetative part of the fungus, which produces enzymes which break down pollutants. ‘Fungal inoculum positively compliments the bacterial communities in soil and in many ways stimulates contaminant degradation’ (Winquist et al, 2013).

Further, with the help of the metabolic activities of plants, pollutants can be degraded in the soil by Phytoremediation. ‘Phytoremediation techniques have the advantage of low cost, no damage to the environment, and high acceptance among local residents as an emerging in-situ green restoration technique’ (Liu et al, 2015).

2.5 Environmental Analysis

Wallis Road is orientated East-West and receives direct sunlight throughout the day on specific sites. With sunlight hours exceeding more than 10h per day in June for the north side of the street and south facing buildings. However, due to the urban morphology, the south part of the street is mainly shaded all year round and only receiving direct sunlight in the afternoon in summer with no direct sunlight in midseason or winter for parts of the street.

London is located in a temperate climate, which typically results in no heat stress (UTCI) in summer and only during midday in moderate heat stress on warmer days. During midseason and winter, slight cold stress at midday and in winter moderate cold stress in the morning and afternoon is detected. With applied shading, the moderate heat stress can be reduced in summer; however, this is also reducing the temperatures for midseason around midday and results in moderate cold stress. The UTCI cold stress levels could be reduced for winter and midseason with additional wind protection, creating overall more moderate temperatures and no heat stress throughout the year, with a slight increase of moderate heat stress on warmer days in summer.

The main wind direction for London is SW with calm to moderate wind speeds and a velocity of max 5m/s. Due to the East-West orientation of Wallis Road, the wind is mainly blocked by the surrounding buildings, creating either an isolated roughness flow with more turbulent conditions on the downwind side and lower velocities near the ground of 0-1 m/s or a skimming flow with the primary wind flow not entering the urban canyon and a low velocity of 0-1m/s at street level. However, the south part of Wallis Road is orientated South-West allowing the wind to enter the side unobstructed creating higher wind speeds in certain areas.

3. Methodology

The method outlined below was followed to create the thesis project. The five key stages are linked in a linear sequence, with each key stage culminating with a milestone.

After the initial key stages 01 Discover and 02 Define the problem is examined and the hypothesis drawn. A first draft (Key Stage: 03 Draft) of the design is created, that leads to the milestone: strategy, and developed in Key Stage: 04 Develop, focusing on the various architectural elements as part of the form-finding process, resulting in the creation of a prototype (milestone), which leads to the final Key Stage: 05 Design, where the prototype is tested and adapted to create variations with the use of parametric tools (Fig. 1).

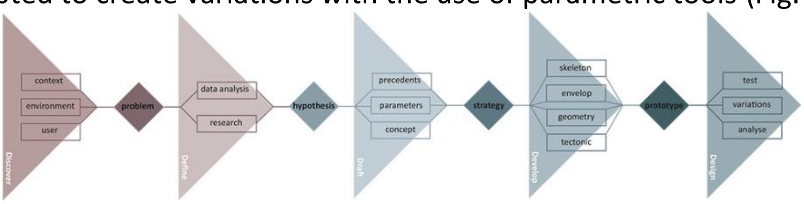

Figure 1. Thesis Project Methodology

4. Results

4.1 Strategy

The sectional approach is applied as a strategy to structure the 500-meter linear street canyon along Wallis Road. Using parametric tools to generate serial sections, creating an urban spine which connects the principal sections. The principal sections are informed by environmental parameters and are designed with passive and active environmental strategies, developing a catalogue of possible variations of the structure.

4.2 Prototype

A prototype is developed to enhance the pedestrian comfort and environmental performance of one of the principal street sections and its microclimate. Besides providing access to the buildings, new pedestrian walkways and cycle lanes are generated. Louvres span across the spine structure and provide adaptable shading and additional protection from downdraft winds. The former street surface is removed, and the soil is treated with mycoremediation; this is applied in sequences, and after 3-6month, the soil has degraded most of the PAHs and pollutants and is ready to be further processed.

Additionally, to the soil regeneration replacing the concrete paved and sealed off asphalt surfaces with grass and vegetative ground cover moderates '...a pedestrian' thermal stress in several ways...by low reflectance (Albedo grass 0.20-0.25), evaporated cooling and low surface temperature'. (Erell et al, 2011).

Due to the groundworks, the street section can be newly designed and generate a new topography to allow for natural water infiltration and flash flood management as well as generating the basis for a new ecological corridor with further treatment of the soil with phytoremediation and specific plants breaking down the remaining pollutants in the ground. The proposed wet bioswale is a trapezoidal-shaped open channel with dense vegetation in the middle of the street and shallow standing water. The water table depth varies according to precipitation level creating a long linear wetland, which temporarily stores water till natural infiltration and the slow settling of particles and bioremediation of pollutants occur (Kwok et al, 2018). The ten-year capacity in the event of a flash flood is set to 800mm with a max. 1000mm, which is orientated on recent flash floods in London in July 2021 with rainfall of 475mm up to 760mm in 24h (Fig. 2).

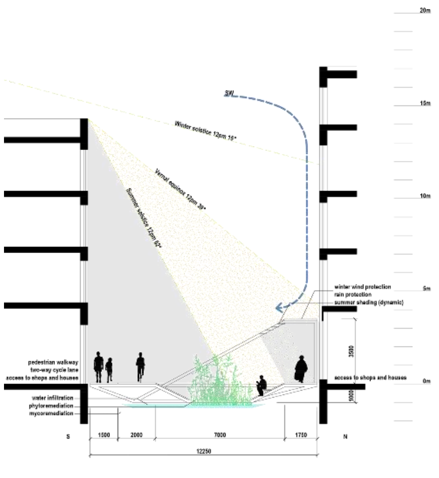

Figure 2. Principal Section and Prototype

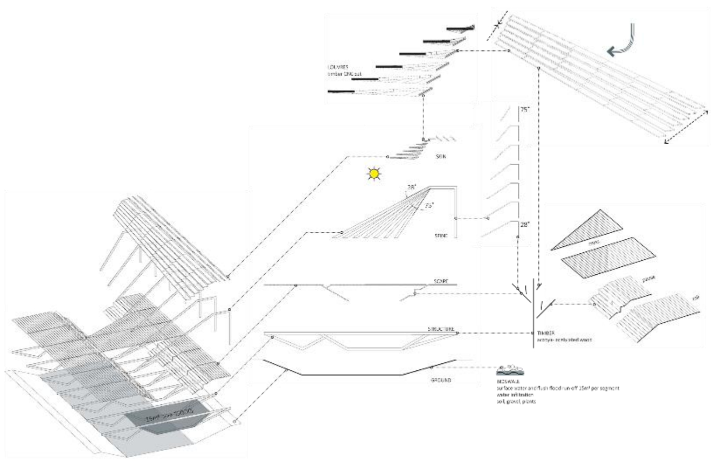

Figure 3. Principal Section Variation

4.3 Variation

Different variations are developed based on the prototype to integrate specific environmental strategies. By developing a sequence of stringed-together prototypes creating a linear structure (Fig. 3).

Different gradients of the spine are implemented along the sequence to adjust to localised received solar radiation in summer, with gradients ranging from 28˚-75°. With areas receiving equivalent or more than a monthly mean cumulative radiation of 150 kWh/m², equivalent to approximately an hourly average radiation of 600 Wh/m², the lowest gradient of 28° will apply to shadow a larger area in the summer. Up to a gradient of 75° for areas receiving a monthly mean cumulative radiation of 75 kWh/m² (approx. 300 Wh/m² hourly average radiation) for a localised shade. Louvres, which act as the shading skin adapt to the different gradients, allow for a continuous surface, and are pivoted to adjust to localised and seasonal environmental conditions.

4.4 Testing

The principal section design is tested with different environmental simulation tools, including ClimateStudio and Grasshopper Ladybug, to analyse its environmental performance (Fig. 4).

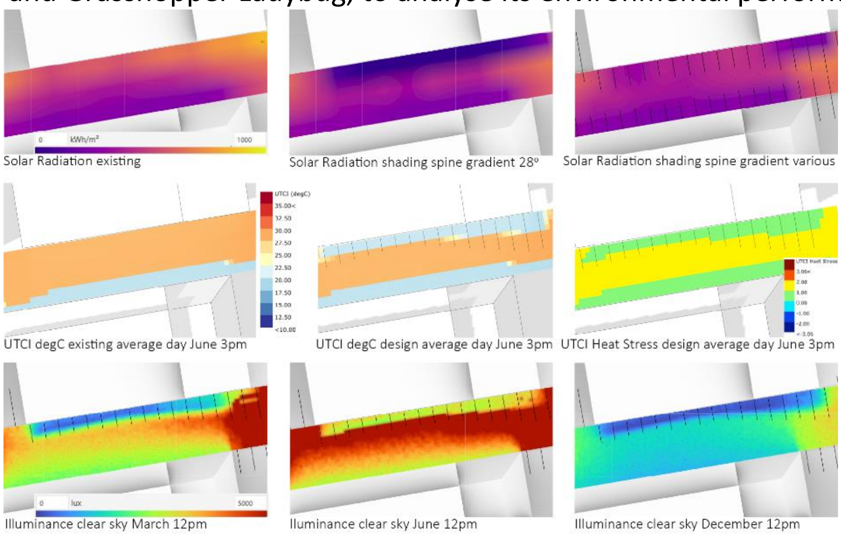

Figure 4. Environmental Performance Variation

The existing street section receives up to a mean cumulative radiation of 846 kWh/m²-yr in certain areas and a monthly mean average of 150 kWh/m² in the summer. Applying shading with a continuous gradient of 28° and closed louvres will reduce the radiation levels to as little as 10 kWh/m²-yr. To allow for a more graduate level of shading, the spine gradient is adapted along the street section with the highest radiation levels of 400 kWh/m²-yr, and a max mean cumulative of 75 kWh/m² in summer.

For pedestrian comfort, the design is tested on a typical summer day in June at 3 pm. The existing UTCI temperatures show for the average summer day in June a temperature of 27.5°C, with a heat stress of 2 (moderate heat stress). For the average day in summer, the temperature under the shading can be reduced by 5°C to 22.5°C and a heat stress level of 1.

As the shading also influences the daylight levels for pedestrians, the design is tested for different seasons and clear sky conditions at midday. In March, the lowest level received is 300 lux in isolated areas. In June a minimum of 1000 lux show the highest daylight levels. In December, the lux levels are distinct lower, minimum levels of 150 lux under a clear sky are achieved.

5. Conclusion

From the performance analysis of the principal section variation, the following results can be drawn from the computer simulations:

Due to the gradient variation of the spine structure and applied louvres, the radiation levels received can be even out along the street with values below a summer monthly average of 75 kWh/m^2, equivalent to no more than an hourly average of 300 Wh/m^2 along the edge of the louvres and shading the walkway during midday and in the afternoon. In summer, the UTCI temperature can be reduced by 5°C under the shading, and no heat stress is experienced. Winter thermal comfort can mainly be achieved through adequate closing and as shown in the analysis, the UTCI levels can be influenced by wind protection, resulting in either no thermal stress or moderate cold stress. Illuminance levels stay in the range under the shading, and adjustable louvres allow for seasonal adaptation. However, when natural daylight levels are reduced, additional lighting is required for winter and evening.

Based on the performance analysis of the design, it is concluded that the project has a positive impact on the overall environmental condition of the street section along Wallis Road. The key findings highlight the benefits, especially for summer and a warmer climate, which in its isolated state might not have a large enough impact on the urban heat island effect but certainly on the local microclimate and initiates the discussion of how the street section and urban public realm are designed for new build as well existing neighbourhoods. With London street‘s cover of 30% for the city’s core (UN-Habitat, 2013) and the future motor vehicle traffic reduction as stated in the London Plan, it opens up the possibility of creating very different street scenarios, which could better adapt to its environment, the pedestrian needs and be more resilient to and mitigate climate change. In the case of London, this means adapting to increased solar radiation levels in summer, higher possibility of flash floods and better ecological treatment of polluted soils to increase natural surface water run-off and infiltration. Due to the timeline and scale of the thesis project, it was not possible to analyse all environmental parameters, and additional simulations to understand the microclimate further, especially the effect of the water bodies, would be beneficial to the project. Nevertheless, the developed prototype and its variation show that it is possible to incorporate multi-criteria design elements on a typical street section of 12.5m width through a systematic approach by multidirectional thinking deriving in a regenerative design for the urban canyon.

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