A FEASIBILITY STUDY FOR GREENING THE GLASGOW SCHOOL OF ART'S BOURDON BUILDING UNDERUSED ROOFTOP TOWARDS THE ENHANCEMENT OF URBAN VEGETATION IN GLASGOW

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Abstract

The Glasgow School of Art (GSA) is comprised of a set of buildings placed next to each other on a valuable urban estate. Partly designed by the renowned architect, Charles Rennie Mackintosh, the campus accommodates a visual treat for tourists, yet it limits the provision of *green* amenity outdoor spaces. There is a dire need to soften its hard surface urban settings with healthy green landscaping and reduce the ambient carbon dioxide (CO_2) levels with due consideration of global warming. This paper is aimed at examining the potential application of urban green schemes to the GSA campus so as to identify their ecological benefits. The impact of the plants on the micro-climate was examined through practical recordings and analysis of the similar urban settings in Glasgow. The results indicate that ambient CO_2 levels can possibly be reduced by over 10% when urban vegetation schemes are applied properly to hard surface city structures. As well, this provides a description of the possible methods of incorporating greens, highlighting the various innovative options available today.

Keywords: urban green, urban campus, ambient CO_2 reduction, microclimate control

1. INTRODUCTION

The GSA campus is located on the Garnet hill in the midst of a busy commercial city of Glasgow. But as it was planned at the time of the city planning it has made its space as a landmark in the existing city map. However, being a stand alone campus, GSA fails to provide any amenity outdoor spaces or *green* spaces for an active campus life. Mostly students are using either the steps at each building access or other hard paved areas for sitting and social interaction. Even in the summer months when there is good enjoyable sun, due to the lack of outdoor sitting spaces, GSA tends not to provide pleasant scenes of the students' campus activity outside the buildings—perhaps, this may somewhat contribute to the creation of a stressful urban ambience and make the students cyber-oriented for their learning activities. It is known that a well planned campus provides the required medium for student interaction and helps in bringing together the different fields and age groups present in an institution for healthy knowledge transfer amongst themselves. Moreover, the green amenity spaces help improve ventilation, unseal hard surfaces, provide shelters, cut energy costs in the surrounding buildings, reduce the urban heat island effect, cut down on storm water problems and make the urban fabrics more attractive and ecological.

2. GREENING AS MEANS OF DEVELOPING AMENITY SPACES

It is quite evident that today the city structure consists predominantly of hard surface built structures, facilities and infrastructure forming the so-called *concrete jungles*. It is thus essential to balance this existing urban fabric which has intensive concentrations of inorganic mass and extensive impervious surfaces, while limited areas having soft and natural landscaping. This imbalance in the urban fabric is not only environmentally harmful but also detrimental in the city functioning. It has thus led to a dire need for introducing planned green spaces within the city structure to act as breathing spaces by counteracting the man-made built environment intelligently. As far as campuses are concerned, green spaces play a very important role in enhancing the school activities and student s' social interaction. There are a number of ways in which these greens can be integrated within and around the urban buildings. Since enough green cover on ground is not achievable in the present situation of dense and compact cities, it calls for a need to use other methods and/or spaces for introducing greens in our built environment (Steffan 2006). Greening the various architectural components in the form of green roofs, vertical gardens or other building integrated green systems, is a rapidly growing phenomenon as it brings a range of practical and psychological advantages to the habitants. In general green urban fabrics may have the following advantages and address various economic, social and environmental issues.

Modify urban microclimate: Considering the environmental issues arisen because of the lack of green spaces, it becomes necessary to address the excessive urban heat. Indeed many cities around the globe have been experiencing that the temperature of its ambient environment is greater than that of its surrounding non-urban areas—this leads to extremely high temperature in urban. Through the daily cycles of condensation and evaporation, plants are able to help cool cities particularly during the hot summer months. In the process of *evapotranspiration*, plants use heat energy from their surroundings when evaporating water. This process leads to the alleviation of the *urban heat island effect*. Rooms under a green roof are at least 3-4°C cooler than the air outside, when the temperatures range is between 25-30°C (Dunnett and Kingsburry 2004).

Temperature regulation inside the building due to thermal insulation: Moreover, the greenery on or along the building skin also helps in controlling the heat flow to and from the building. The plant layer, whether on the roof or the façade, forms part of the insulation for the building. The plants and the growing medium in the green roof keep the roofing membrane cool by the direct shading, evaporative cooling from the plants and the growing medium, additional insulation values from both the plants and the growing medium, and the thermal mass effects of the growing medium. It enhances internal energy efficiency in the building (Brad and Bas c2001). This results in not only reducing the overall energy consumption but also lowering greenhouse gas emissions.

Improved air quality: Extensive planting within built environment is also a widely recognised means of improving air quality. Urban vegetation contributes to the reduction of a number of air pollutants not only through the plants themselves, but also by deposition in the growing medium.

Water issues: Green roofs also mimic natural drainage which helps remove pollutants from urban surface runoffs. This leads to the development and promotion of sustainable urban drainage systems.

Health and psychological benefits: The incorporation and integration of biomass into the built environment will soften the hard-looking built form and modify the appearance of the conventional environment of built structures and facilities. The presence of plants in urban settings somewhat contribute to reducing the stress levels of humans; thus it improves the wellbeing (Dunnett and Kingsburry 2004).

For a better understanding of the effects of green spaces over the existing urban built environment, a case study was conducted. The University of Strathclyde, which is also located in the city of Glasgow, was selected for the further practical measurements of the green urban campus as to temperature, ambient CO_2 and relative humidity levels.

3. CASE STUDY: UNIVERSITY OF STRATHCLYDE URBAN CAMPUS

The University of Strathclyde (UOS) has a large city campus which spreads over 25 buildings but all placed comfortably close to each other. The UOS campus is similar to the GSA being organised around some vehicular roads and is not located in a single enclosed zone. However, the campus planning is such that it does provide a number of good green spaces enhancing the scope for the students' and staff's campus activities. Just to match the scale of the GSA Bourdon building, the Curran building was chosen from the University of Strathclyde campus. To understand the effects of green plants on the urban campus, three environmental parameters, such as temperature, relative humidity and CO_2 levels, were measured on site (Fig 1).

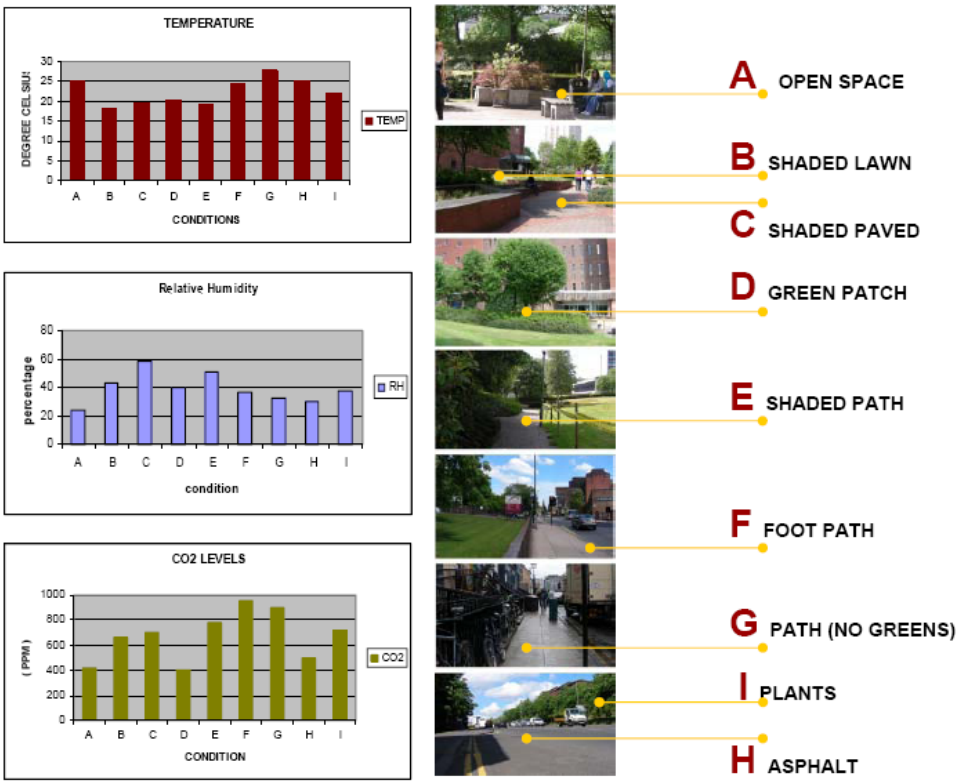

Figure 1: Ambient temperature, relative humidity and CO_2 levels of outdoor campus spaces selected

The readings were taken with the help of a hand-held meter under different site conditions selected and were then compiled in the form of bar graphs for the further comparative analysis.

The findings of this case study can be summarised as follows:

- Tree-shaded areas covered with grass reduce the ambient temperature roughly by 5°C when compared to other sunlit hard surface areas.
- Green-covered areas reduce the ambient CO_2 by 10-20% as compared to hard surface open pathways.
- Urban green spaces increase relative humidity levels.

These results reinforce the fact that the presence of green plants helps create healthy urban climate. With due consideration of these aforementioned urban-green benefits, the status quo of the GSA campus was re-examined and the potential upgrade was proposed.

4. POTENTIAL UPGRADE: BOURDON BUILDING UNDER-USED ROOFTOP

According to the on-site measurement, the ambient CO_2 level around the GSA campus was significantly higher than that around the University of Strathclyde campus (Fig 2). It can be easily assumed that this tendency derives from the lack of the GSA estates' green spaces and this situation may be contributing to degrading the school's outdoor campus life, ambience and air quality today. In order to upgrade the GSA estates and campus life, the aforementioned urban green schemes have been taken into consideration.

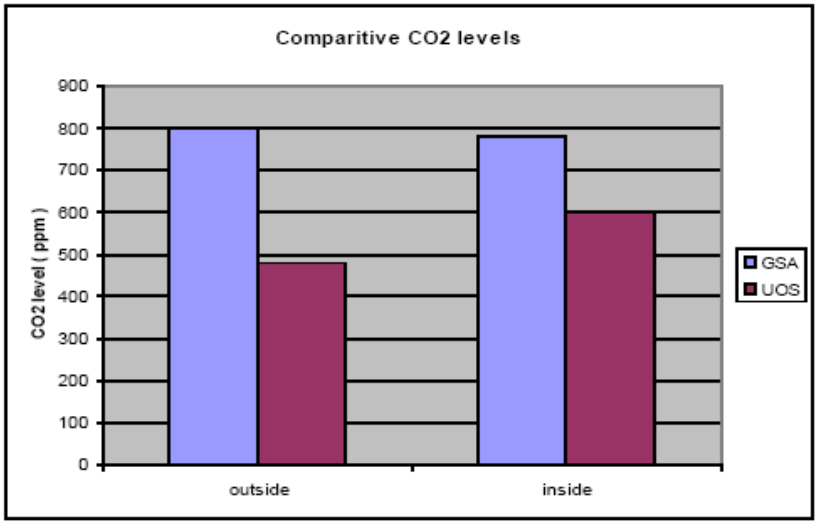

Figure 2: Ambient CO_2 levels inside and outside the buildings of The Glasgow School of Art and the University of Strathclyde

After the investigation of the GSA properties, it was confirmed that the school has some outdoor spaces that are currently underused and can be converted into the urban green spaces. One of the potential sites was the roof terrace adjacent to the Bourdon building, where the Mackintosh School of Architecture is based (Fig 3). This site is located on the basement of the building and serves currently as an outdoor storage for some of the school's old furniture. The Bourdon building sits along the north south axis; however, the roof terrace selected for potential conversion falls along the east west axis. The site selected may need to receive adequate sunlight during the afternoon hours ideally for all seasons for plantation. Considering that the rooftop has the potential for conversion into an accessible sitting green outdoor space, the orientation and obstructions that may hinder its response to the sun path in Glasgow were analysed using the Ecotect™ environmental simulation software tool (Fig 3). Three dimensional digital models of the Bourdon building and the surrounding buildings located in the Garnet Hill area were developed. The sun positions were examined particularly between 12pm to 2pm. The sun hours were set with due consideration of the school's lunch break when most of the students and staff would like to sit out—especially in the spring and summer months. The results of the day-lighting analysis show that the selected roof terrace receives sufficient sunlight almost around the year in the stipulated timings of the day.

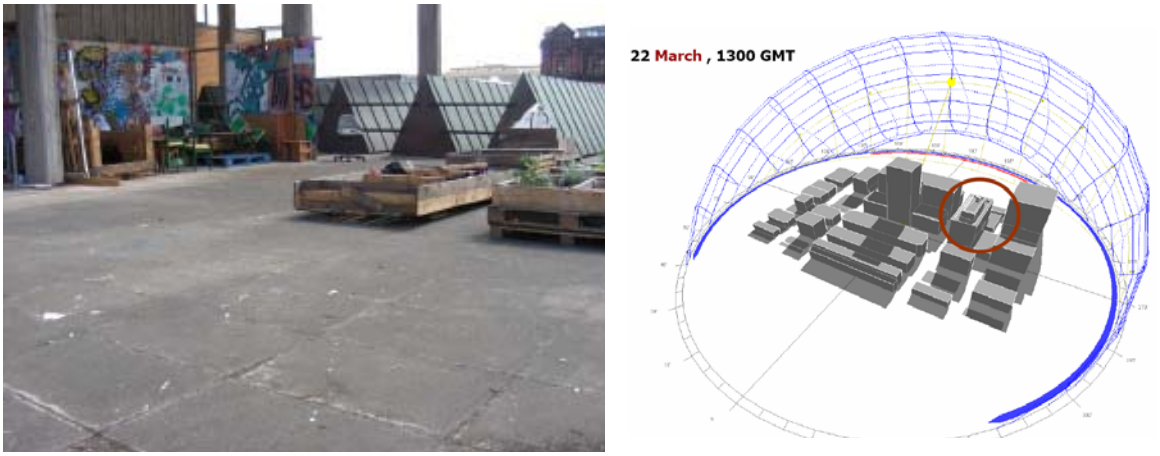

Figure 3: The GSA urban campus roof terrace
Left: The existing state of the selected roof terrace adjacent to the GSA Bourdon building
Right: The Ecotect™ day-lighting and sun-shading simulation result of the GSA Bourdon building and the Garnet Hill area

Based on the examination of the day-lighting and sun-shading patterns, the GSA campus green upgrades were proposed (Fig 4). In this proposal, an accessible green roof system that has been rarely implemented in the urban building in the Great Britain was introduced. The actualisation of this project requires more detail analyses of the project's cost, quality and time aspects; however, as an initial attempt, this study successfully increased the GSA executive committee members' awareness of the significance of the urban vegetation and the accessible green roof system that can help improve the campus life, ambience and air quality, while reducing the negative environmental impact.

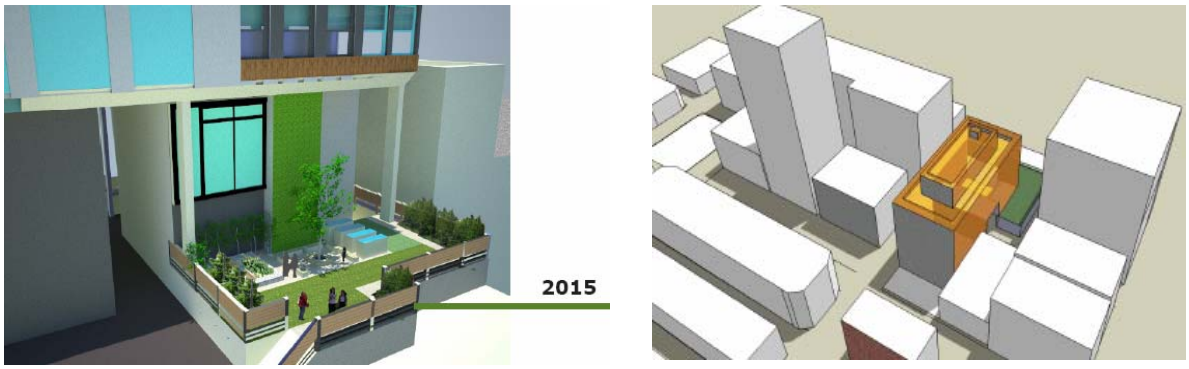

Figure 4: 3D images of the proposed accessible green roof system applied for greening the GSA roof terrace selected

5. CONCLUSIONS

This feasibility study led to some evidence that greening outdoor spaces generates positive effects on lowering the ambient temperature and CO_2 levels as well as increasing the humidity level—i.e. the alleviation of heat island effects. The installation of a green roof on mono-functional or underused urban buildings' rooftops is one of the practical solutions for increasing the area of urban vegetation that leads to the partial improvement of the public health and wellbeing. With consideration of these benefits reviewed, a potential green upgrade for the GSA urban campus was examined and an accessible green roof system that has been rarely applied to urban buildings in the Great Britain today was proposed for the creation of the Bourdon building's green roof terrace.

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