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Bio-Facades; An Innovative Design Solution Towards Sustainable Architecture in Hot Arid Zones

Fodil Fadli¹, Payam Bahrami², Irina Susorova¹, Meysam Tabibzadeh², Sara Zaina¹, El-Shaimaa El-Ekhteyar¹

¹Qatar University, QA

²Optim Design Inc., US

Email: f.fadli@qu.edu.qa

The United Nations forecasts that 70% of the World's projected population of nine billion people will be urbanized by the year 2050, a 51% increase from seven billion people urbanized as of 2010. The enormity of this total figure of 2.8 billion people moving into cities over the next 40 years is can be more clearly appreciated when converted into an annual rate of 70 million people per year, or a daily rate of nearly 200,000 people. This means that the human race needs to build a new city of more than one million people every week for the next 40 years to cope with this urban growth (UN, 2011).

Creating comfortable urban and building environments is challenging in hot climate conditions of many countries of the MENA (Middle East and North Africa) and Gulf region, such as Qatar. Hot ambient air temperature and a high level of solar radiation lead to large heat gains through building envelopes. In addition, heat gained by building surfaces is emitted back into the atmosphere which leads to the increase in ambient air temperature in urban environments. This phenomenon is often called the urban heat island (UHI) effect. As a result, buildings constantly have to rely on mechanical cooling systems in order to achieve comfortable indoor conditions. To balance the weather conditions of hot climates, buildings generally require a large amount of energy for cooling consumption.

Buildings located in hot and arid desert environment of the MENA and Gulf region traditionally relied on different passive measures and devices for cooling and ventilation. These passive measures based on natural phenomena included natural cooling and ventilation by wind, evaporative cooling from water, and shading from the sun. Typically, buildings combine a few passive cooling techniques that give a distinctive look to MENA region architecture in its multiple variations from North Africa to the Middle East, and from the Gulf to Levant countries. For example, buildings often include one or two wind towers that capture strong wind high above the roof and redirect it down into the building core for cooling and air circulation (Oliver, 1998).

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The link between humans and nature becomes important as more than 50% of the World's population lives in cities. In the last 20 years as part of the environmental sustainability movement, there was a new interest in incorporating plants into building construction, including buildings with green roofs and green walls. The significant positive effects of vegetation and landscape elements on building thermal and energy performance and the urban heat island effect are well known. Many countries located in hot climates had the tradition to grow vines along building perimeters and above atria to provide shade from excessive sun exposure and to cool the air. The recent sustainability movement has renewed the interest in integrating plants into various architectural features, such as building roofs, facades, or atria. While green roofs covered with layers of vegetation have long been prominent features of buildings in many cities, green walls integrating plants into buildings' vertical elements are still a relatively new architectural concept (Dunnett & Kingsbury, 2010). We can learn valuable lessons by adopting design concepts from indigenous buildings and architecture (Fadli & Sibley, 2009).

The purpose of this paper is to discuss the bio-facade concept and its benefits as an environmental solution for creating a sustainable architecture and urbanism in hot climate areas such as MENA region. Bio-facades can be considered to new or existing building construction of commercial, residential, and public buildings with great imagination by using such architectural features as green walls, hanging gardens, green roofs, or pergolas. In addition to their striking visual effect, vertical vegetation increases building energy efficiency, creates a positive effect on the psychological and physiological health of individuals, helps mitigate the urban heat island effect, reduces greenhouse gases, improves air quality by acting as a bio-filter, protects wall construction materials from ultraviolet radiation, reduces noise pollution, and creates natural habitat areas in cities. These benefits create a path towards making cities more environmentally sustainable. Bio-facades can be incorporated either into the traditional courtyard architecture or contemporary buildings to create a better microclimate, to provide shade, and to reduce energy consumption, enhancing the energy performance of building envelopes, the buildings themselves, and their surrounding environment.

The current study led by the authors, indicated that bio-facades can be used as an environmental sustainable solution for energy efficient building in different climates. This paper will answer the questions: "How does bio-facades may create sustainable architecture and urbanism in the hot and dry climate and what are their benefits?", "how does bio-facades affect thermal and energy performance of buildings in the hot and dry climate?"

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