An Analysis of Passive Design Strategy for Diamond Lotus Riverside High-Rise Apartment Project in Ho Chi Minh City

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Abstract. Sustainable development is the key goal that most of the current architectural trends, including green architecture, have been targeting. In order to achieve that goal, energy conservation in buildings is always the prioritised aspect to be considered carefully during the design process, especially in green buildings. Among many solutions for energy reduction, the passive design comes first and has been long-term effective during the building life cycle. Located in Ho Chi Minh City, Diamond Lotus Riverside is considered the first high-rise apartment of a Vietnamese investor that applied for both LEED and LOTUS green building certification at the gold level. The survey results show that this project has achieved LOTUS provisional certification and significant energy-saving indicators. This research focuses on the analysis of the passive design strategy that has been carried out in the Diamond Lotus Riverside project. From there, lessons can be drawn for designing energy-efficient high-rise apartment buildings in HCMC and Vietnam in general.

Keywords: Passive design · High-rise apartment · Green building

1 Introduction

Green building is the stepping stone towards sustainability, achieving national sustainable goals, and the global movement. Green building development helps to reduce waste and pollution; prevent environment damaged; and protect human health. In the context of rapid urbanism in Vietnam, the development of high-rise residential buildings is unavoidable and trending because it can offer shelters for many citizens in high-density areas. However, those buildings regularly consume a large amount of energy and emit a vast amount of CO_2 during operation. Developing this building type towards sustainability, particularly applying green standards, is a possible solution for the available issues [4].

Green residential buildings provide a better living environment for many people. In green buildings, the well-being, the strong relationship of the community, and residents' perception and behaviour have been focused on and improved. Diamond Lotus Riverside

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(DLRS) can be considered as the first and typical high-rise residential building which is implemented international green building standards such as LEED and LOTUS [6]. The project, developed by Phuc Khang Corporation (PKC), is located at Le Quang Kim Street, District 8, Ho Chi Minh City. The land area is 16,800 m^2; the construction area is 3200 m^2. The building density is remarkably low at 19%. The whole building includes three blocks, connected by the two bridges over the roofs. Therefore, that creates a green sky park with a good view to all directions, such as towards the canals, and central districts such as District 1, 3, 5, 7 and 8. The building has a podium and 760 apartments, each with greenery loggia. DLRS has an 8000 m^2 park next to the river with 300 m long. The ecosystem at this park has been reserved and developed for biodiversity.

Most green building rating systems consider passive design as a prerequisite credit that the buildings have to achieve [3]. At the very first step of the design process, green buildings as well as normal ones in general need to be naturally adapted to the existing context, before improving the building performance by technology. Therefore, passive design should be applied from the beginning of the project. Passive design is "the design that maintains a comfortable temperature within the building using the climate and natural elements to get the optimum benefit and to reduce or eliminate the independence on mechanical systems for heating, cooling and lighting" [1]. Based on the definition, the passive design principle can be listed as passive cooling and efficient daylighting.

2 Passive Cooling

Passive cooling strategies apply to the countries around the equator where the climate usually has a high thermal theme and overheating regularly occurs in buildings. Especially, in hot and humid areas like Vietnam, the applied strategy is more specific in reducing indoor temperature. The common unwanted heat in buildings includes direct solar heat gains through windows, heat transfer through roofs and walls, and internal heat gains from occupants, equipment, and electric lighting [2]. Therefore, reducing the heat gain and releasing internal heat are suitable for cooling the indoor environment.

2.1 Heat Gain Reduction

The cooling requirements for buildings largely depend on the heat gained from solar radiation. Reducing the solar heat gain remarkably impacts decreasing the energy consumption in buildings.

The building mass of DLRS significantly contributes to indoor thermal conditions. It stretches towards nearly East–West and thus reduce most of the excessive solar radiation to the apartments, as shown in Fig. 1. Figure 2 shows that the greenery covering the facade and the roof helps to provide shading and thermal insulation. The heat gain from solar radiation, therefore, reduces noticeably. It leads to the fact that the energy use for air conditioning systems is considerably reduced. That contributed largely to the reduction in the total measured energy consumption. During the operation phase, total energy use decreased by 55.1%, lower than the recommended baseline from LEED.

The facade areas facing west are less than 10% of the total facade area, and only less than 15% of the west facade is glazed. As a result, the extreme heat gain from the west affects the insignificant facade area.

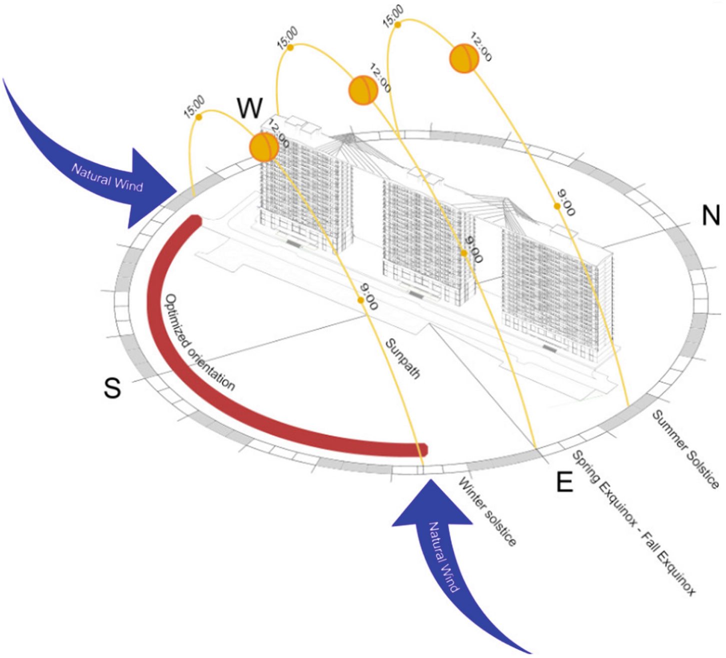

Fig. 1. Building mass and orientation of DLRS (*Source* authors)

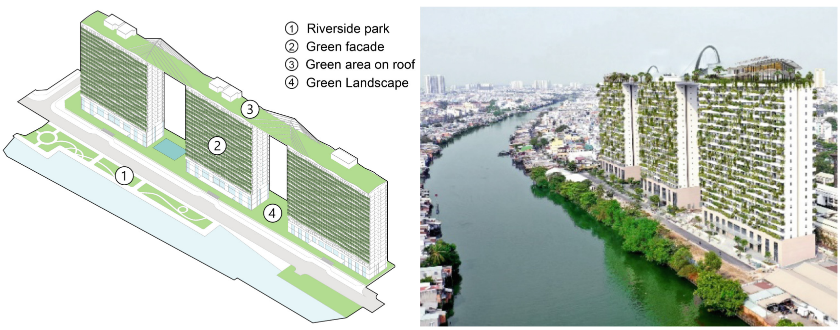

Fig. 2. From left to right: Greenery system; green façade of DLRS (*Source* authors and PKC)

The external walls are made of autoclaved aerated concrete blocks with a thickness of 220 mm. The U-value of this material is 0.6 W/m^{2}K, which is lower than the recommendation of the standard QCVN 09:2017/BXD [5] about energy efficiency in buildings. It indicates that the external walls have good insulation capacity and provide higher thermal performance.

Apartments of DLRS have loggias, instead of balconies. The loggias are 1 m deep enough to provide transition space and shading but are still effective in daylighting access. Moreover, all windows and doors at the loggias, which receive direct sunlight, used the tripled low emissivity glazing to reflect the heat from the outdoor environment, reduce solar radiation and UV rays, and minimise heat storage.

Greenery is one of the main features of DLRS. On the roof, 15.4% of the area is covered by grass and trees. In addition, every apartment unit has green trees at the loggia. Figure 3 shows the typical planting area at each loggia. This green envelope covers and protects the building from the effect of solar radiation and high air temperature outdoors. There is about 4571 m^2 area total for planting trees at the loggias. Compared with the built area of 3242 m^2, the greenery area is much larger and can be compensated for the constructed area. This green envelope covers and protects the building from the effect of solar radiation and high air temperature outdoors.

Fig. 3. Greenery at the loggias (*Source* authors)

2.2 Internal Heat Dissipation

Natural ventilation is one of the most effective heat dissipation strategies, greatly enhancing thermal comfort and indoor air quality. Then it leads to a remarkable decrease in energy consumption for cooling the buildings.

The building is split into three thin blocks that enhance the wind effect in each building block. Also, the building facing the Tau Hu Canal and the Doi Canal may get the local winds from those canal directions. As shown in Fig. 4, each block of DLRS has openings at the ends of indoor corridors, allowing the wind and fresh air to come through the building. Therefore, the natural ventilation is enhanced in the common area and each apartment. It implies that the demand for using air conditioning systems could be reduced. Furthermore, the courtyards between blocks include greenery and a swimming pool that provide moisture and the possibility to have evaporation cooling.

3 Daylighting

One of the most valuable green features is that all apartments have outstanding views of the canals. The building orientation allows the daylight from North or South to come to all main living areas in the apartments but also reduces the effects of extreme sunlight from East and West. The building, as well as each apartment, has a linear form with a narrow width; therefore, the daylighting can reach further indoor areas.

Fig. 4. A typical plan of DLRS (*Source* authors)

In DLRS, the side lighting strategy is mainly applied in each apartment (the openings have been highlighted as shown in Fig. 5). A full-glazed door introduces daylight into the living room of each apartment. Furthermore, every room has access to daylight via windows. Hence, it improves the occupants' comfort by having a visual connection to the outdoors, especially to the view of the canal, which is quite hard to achieve in a dense city. Although direct sunlight causes heat gain and glare issues in the indoor environment, the glazing layer is Low-E glass can help to reflect the outside heat and solar radiation. Also, the occupants do not use curtains as the Low-E glass reduces glare. Regular glasses are used to get more daylight for the area without direct sunlight. The white colour and smooth interior surface improve the lighting reflection and achieve the best daylighting efficiency.

Fig. 5. Typical section of a 3-bedroom apartment in DLRS (*Source* authors)

In 2014, UN-Habitat recommended that the glazing ratios are commonly between 25% and 50% of the external wall for daylighting [7]. At DLRS, the glazing ratios of the facades facing nearly South, and North are around 20–35%, as shown in Fig. 6, so the need for artificial lighting considerably reduces.

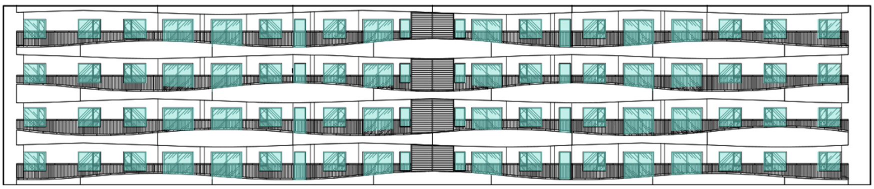

Fig. 6. Doors and windows of a typical apartment in DLRS (*Source* authors)

Windows and doors to the loggias have proper shapes, window-to-wall ratio, and glazing types (doubled glazing, Low-E glass with the U-value of 1.62 W/m^2K) to balance daylighting requirements versus the need to reduce solar heat gains (energy saving and thermal comfort).

4 Conclusions

A passive design strategy has been applied from the beginning of the DLRS project at the design stage. Based on the design solutions for passive cooling and daylighting, the buildings have achieved significant energy savings and full daylighting access to the apartment. Also, 100% apartment offer the occupants a spectacular outside view of the canals. The applied passive design provides an essential and energy-efficient stepping stone for the next phase when the active design is taken over to maximise the indoor comfort for the occupant and allow them to have more control over their living environment. The DLRS project is concrete evidence that passive design can benefit high-rise residential buildings. The success of this project encourages all parties related to the built environment to move forwards to climatic responsive design, green building and then sustainability.

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