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**Master Thesis Defense**

Entitled

*DETERMINATION OF THE COST OPTIMUM PASSIVE COOLING DESIGN SOLUTIONS FOR RESIDENTIAL BUILDINGS IN UAE: THE CASE STUDY OF SHARJAH GOVERNMENTAL VILLAS*

by

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Abstract

Over the last three decades, UAE has experienced a rapid track development and has been ranked as the world's highest construction activity per square kilometer. The largest energy consumer and the largest contributor to Carbon dioxide emissions in UAE is the building sector, using an average of 60% of the total electricity. The residential sector, which consumes about 30% of the total electricity consumption in the UAE, is a major concern of the national strategies and regulations (DEWA, 2017). This thesis aims to determine the optimum passive design solutions of the residential villas, in the hot and arid climate of UAE. The optimization methodology will consider both the environmental and economical aspects of the construction and operation phases of the building's life. It evaluates selected passive alternative solutions, including building orientation, configuration, insulation materials and thickness, glazing characteristics, cool coating, and exterior windows' shading; to find the cost-optimum house design out of a baseline house model.

Two case study villas were selected, which are following the typical design of the local governmental villas (GVs) of Sharjah. The two semi-detached villas selected for this study include a one-story small 'G-villa' with an area of 97 m<sup>2</sup> and a two-story 'G+1 villa' with an area of 256 m<sup>2</sup>. They mainly differ in the architecture program, construction details, occupancy pattern, and HVAC schedules. The methodology of this study will be based on the literature, data gathering of the technical drawings of two case study villas, and the prices/cost of the evaluated passive alternatives. The optimization process will use the manual selection of the passive techniques alternatives based on UAE market availability along with the dynamic simulation (DS). The DS will be conducted using DesignBuilder software that embraces EnergyPlus engine, which will be validated and collaborated using real electricity bills of one full year (2019). The DesignBuilder DS simulations will be performed to find the annual energy consumption of each alternative. Finally, the total cost analysis of the building calculations will be done using the 'Net present value' economical approach of the annual energy cost of 20 years life-span and the initial cost of each alternative. The alternative that has the minimum total cost, which takes into account the operation energy and initial cost, will be considered as the optimum solution. Each passive strategy alternatives will be analyzed separately and then to combined in one optimum model. The G-villa optimization results showed that increasing the initial investment by 73.59 Dhs/m<sup>2</sup> to decrease the annual energy cost by 31.52 Dhs/m<sup>2</sup> is the optimum solution, which can be achieved by having a new north-oriented configuration, 7 cm XPS wall insulation, 8 cm XPS roof insulation, glazing with a U-value of 2 W/m<sup>2</sup>K and SHGC of 0.29, and a roof cool coating. On the other hand, the G+1 villa optimum solution is to increase the initial investment by 19.81 Dhs/m<sup>2</sup> to decrease the annual energy cost by 7.34 Dhs/m<sup>2</sup> by having the front façade to be north-oriented, 15 cm XPS wall insulation, 12 cm XPS roof insulation, glazing with a U-value of 1.9 W/m<sup>2</sup>K and SHGC of 0.26, 0.1m Aluminum louvers on the west and south façades.

The optimum model can help in enhancing the development of sustainable housing design, which achieves the most appropriate balance between the sustainability dimensions in the UAE. Additionally, this methodology can be linked with a local rating system like the Estidama villa pearl rating system or Sa'fat to solve the real conflict problems of the economical and environmental aspects. Also, it will allow the comparison of different sustainable houses. For that, the expected impact of this research is to promote sustainability into commercial and governmental applications by introducing the optimum villas that are tailored for the UAE context in terms of climate, market, and culture.

**Keywords:** cost optimization, sustainability, passive strategy, energy simulation, DesignBuilder, UAE green building rating system, and UAE governmental villas.