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ABSTRACT

Sustainability in architecture must produce buildings that are "taking less from the Earth and giving more to people." [1] in other words it should give satisfaction for people with less energy consumption thus less environmental pollution. Sustainable architecture involves all stages of design, construction, operation, maintenance and demolition. The sustainable design adopt passive design strategies that produce buildings which use the wind for cooling and the sun for lighting and heating [2]. Some of these strategies were used in the past, and re-adopted in the present time like courtyards that enhance the thermal performance and ventilation of the buildings, especially in the hot areas. In this research there will be an investigation about the efficiency courtyards to highlight its capability as passive design solution in improving the thermal performance in school buildings.

Passive design is applied in the buildings to enhance the interior thermal environment with minimum energy usage [3]. The passive design does not include electrical and mechanical support, mainly it is respond to the climate (wind and sun path), the requirement of the location, the local available materials and many other factors. There are many passive design strategies related to the building orientation, insulation, shading devices, usage of courtyards, ...etc. [4]. Courtyards assumed to be successful passive design strategy that was used many years ago ever since the Neolithic settlements as a result of the reaction with the climate and social requirements, therefore, the courtyards gave protection from the outer forces and dangers. Courtyard is a surrounded space in a building that is open to the sky, regardless of the types of spaces and enclosures [5]. Usually the courtyard represent the base cell for the houses' spaces and rooms around it. Courtyards can have different shapes but Reynolds [6] stated that most of the traditional courtyards got rectangular or square shape, meanwhile Edwards et al. [7] stated that there was circular courtyards in the vernacular architecture, Courtyards types include closed, semi closed and semi opened forms.

Several researches were presented to assess the workability of the courtyard in the contemporary architecture and its influence in improving the thermal conditions of the interior rooms around it, Reynolds [6] mentioned that the thermal mechanism of the courtyard is determined by its proportion, the adjacent masses and the inhabitants activities in the courtyard, in addition to the use of shading elements and landscape inside it. Hyde [5] recommended three strategic fundamentals in the design of the courtyard including; macroclimate airflow, the orientation and lastly the economic restrictions. Acosta, Navarro and Sendra [8] stated in their study the importance of courtyards in enhancing the ventilation in the houses. Yang & Kang [9] argued that the trees in the courtyard can control the sound fields thus minimize the noise, in addition to its role in improving the thermal situations. Actually courtyards proved by time its progressive interaction with the environmental forces which enable it to assist the building in a positive way for daylight, shading, cooling, ventilation, ...etc.

In the Islamic city the courtyard assumed to be a significant component in the urban tissue and had importance for both function and culture features, as it deliver thermal wellbeing for the inner spaces and provide isolated outer space for the inhabitants particularly for women [7]. A good example of the traditional courtyard is in Al Bastakiya in United Arab Emirates. The Bastakiya urban tissue shows integration of different types of courtyards on the urban level and in the houses. Another type of noticeable courtyards was which is the courtyards within the houses and they were smaller than the public courtyards and had wonderful feeling of privacy with cool breeze. The private courtyard was located in the core of the houses and act like the lungs for the house ventilation, where it provided microclimate within the house which maintain thermal comfort night and day by enabling special wind circulation inside it. Most of the private house courtyards had three surrounding walls with openings as windows and doors for the adjacent rooms and spaces, while the forth wall was arcade which gave more shaded area for the house and act like transmission zone for the inner private rooms.

The courtyard was ignored in the contemporary design and architecture after assuming it as old fashion strategy, but after many researches was conducted to evaluate efficiency of courtyards an increasing awareness occurred about the power of the courtyard in handling the environment forces especially in hot arid areas like UAE. Mitchel in [10] declared the importance of studying and analyzing the old traditional buildings, and he focused on the courtyard as a role of tradition that can be transmitted to contemporary architecture in the gulf region, he argued that the new courtyard houses in American university of Sharjah(AUS) campus in UAE can be a true evidence and a good example for the applicability of courtyard in the contemporary buildings and houses. Many architectural designers these days are ignoring the traditional passive design strategies in their designs of buildings, which force inhabitants to use the technology in the buildings to accomplish satisfaction in the interior environment spaces, and that cause usually high energy consumption thus environment pollution. Courtyards is a good passive design strategy which can contribute in enhancing the thermal performance of the building especially in hot areas. This research will investigate the effect of closed courtyard with different proportions on school building in Sharjah – UAE, to test the capability of the closed courtyard in improving the thermal performance of the school consequently minimize the energy consumption. However, this research will define the proportions of optimum courtyard.

Consequently, the aim of this paper is to optimize the efficiency of the courtyard as a passive design strategy in the environmental context of UAE. In order to achieve the overall aim several objectives, this includes adopting an idea of passive design solutions, mainly courtyard to prove its capability in producing sustainable architecture, carrying out a acritical review about the courtyard including a time line for it, selecting a case study (school building) and investigating the effect of courtyard on the building by enhancing its thermal performance.

The research will adopts a qualitative methodology depend on descriptive and comparative analysis for a case study after computer simulation, the case study will be a school building in Sharjah. IES software will be used for the simulation of the case study to investigate the environmental performance of the courtyard in the school building. Crawle et al. [11] highlighted that IES software is pioneer for simulating environmental behaviour.

The case study was chosen as school because the courtyards is used mostly in houses while it can be beneficial for public buildings like schools as courtyard can provide the school with private outdoor space, and can improve the thermal, acoustic, ventilation of the building thus minimise the energy

consumption, beside that the courtyard can provide the school with save inner playground and learning scientific atmosphere for the students .

The case study is Al Murooj English school which is located in Sharjah in UAE. Sharjah is the third largest city after Dubai and Abu Dhabi in the UAE. The climate of UAE is typically desert dry climate, because it is located in the Northern belt of desert.

Speaking of the research analysis scope, this research will focus on the proportions of the courtyards is important as it define the thermal impact of the courtyard , as if the courtyard is too narrow it will be like corridor, and if it is too wide it will be like open area without any effect on the surrounding buildings. Koch-Nielsen [12] stated that the proportions of the courtyards influence directly its thermal characteristics and the thermal characteristics of the nearby rooms, while the preferable proportions for the courtyard are starting from x to $3x$ length , where x is the courtyard height (Figure 1).

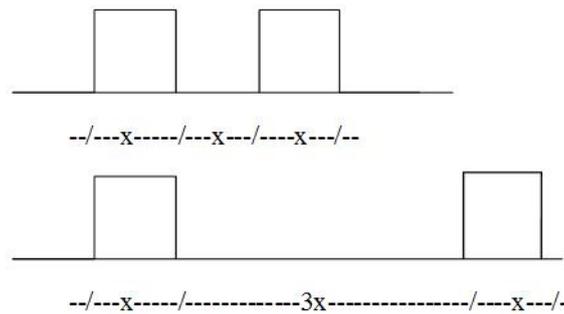
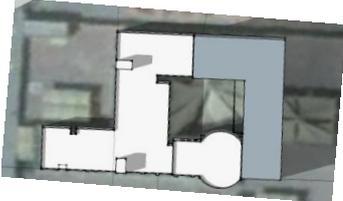


Figure 1: The recommended proportions for the courtyard from x to $3x$ width where x is the courtyard height (source: Author after Koch-Nielsen, 2013)

In the research there will be investigation of the thermal impact of the courtyard in two different proportions which was suggested by Koch-Nielsen by using IES software and those are $2X$ and $3X$ and the proportion of $1X$ will be ignored as it is not suitable for public building because it produce small courtyard that suits more the houses ,but there will be investigation for a new proportion which is $4X$ to check the validity of Koch-Nielsen theory .The investigation will be in three stages explained in (Table 1), to find the optimum proportion for the courtyard in school building of the case study that will provide the school with the best thermal performance.

Table 1 the Stages of the research approach

Stages of the analyses	Top view of the simulation cases	Elevation of the simulation case
The first stage with width $2X$, where x is the courtyard height .		



As a concluding remark, the courtyard was a climate responsive in the past, that provided people with easy direct solutions for their problems with the climate, and it was able to satisfy their social needs. The courtyard in the present time started to attract the designers as good passive design solution for the sustainable architecture because of its good thermal performance, but its optimum proportion is still under investigation to reach the desired ratios, which is more suitable for the contemporary architecture. It is clear that the future architecture will use courtyards but in new ways that suits the new architecture styles in modern high-rise buildings and in public and private ones, as no one can deny the capability of the courtyard to handle even partially the climate effect in a positive way .

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