Energy Management and Façade Design in Prison Buildings in Hot Climates:

The Case Of Abu Dhabi

Nawal Al-Hosany

Keywords
Abu Dhabi, prison building, energy consumption and building envelope

A B S T R A C T

This paper aims to investigate the impacts of the building envelope design on energy consumption in prison buildings in Abu Dhabi. Unlike other buildings, prison buildings require constant use of their spaces. The configuration of the prison building has also specific characteristic. The study will investigate the particularities of use of prison buildings envelope in relation to energy performance.

INTRODUCTION

The aim of this paper is to investigate the impacts of the building envelope design on energy performance in prison buildings. Abu Dhabi has witnessed a sudden and complete transformation in many tracks. The construction and building sectors experienced the most noticeable changes in the accelerated development in UAE. The traditional Architecture has disappeared under the stream of the new technologies and sophisticated building systems.

The recently developed version of building codes and regulations was released in 1994 to be implemented in May 1998. Unfortunately, energy issues and climatic factors were not properly addressed.

No serious guidelines for the envelope design and the façade elements have been suggested. No codes for skin material or glass specification (one exception the use of reflected glass have been indicated).

As a result of the fast development without considering the energy consumption, the electric consumption has increased from 540 GW/H in 1975 to 7000 in 1997 (Water and Electricity Department, 1997).

Figure 1 shows the rapid expansion in the use of the electric consumption and buildings in Abu Dhabi have proved that an average of 44% of the electric consumption is used for air conditioning (El Kadi et al, 1999). Also Numan (1998) claimed that the disproportionate demand for electrical energy by residential buildings in the gulf region is due to high reliance on A/C systems for control of internal built environment.

Different case studies to investigate the facade influence on the thermal load in many different cities with similar climatic conditions (Abu Dhabi, Texas, Hong Kong), shows that the facade can contribute up to 40% from the total thermal load. (El Kadi et al, 1999).

THERMAL PERFORMANCE OF FACADES IN PRISON BUILDINGS

Historical Review of Prison Design

A historical review of the development of the building environment of prisons revealed the strong relationship between the types of design and concerns of comfort and environmental awareness. Earlier prison buildings were not
Research Paper

FORUM

concerned with comfort conditions. It did not regard the ventilation and hygiene issues. The effective measurements for a good prison design at that time meant two things only: maximum security and brutal treatment (e.g. The Bastille, Paris). Improved prisons date from the 18th century. It was not until 1773 that adequate light and air were introduced in prison buildings design (Ghent prison) (UNSDRI, 1975). The concern for prison conditions and the prisoner’s health along with the changing trends in penal philosophy in the 19th century led to consideration of the design of the envelope (e.g. Millbank prison, London 1821). Design of modern prisons emphasises comfort accommodation for the inmates.

The advanced building techniques and skills are deployed toward treatment and reintegration of the offender into society. The larger the prison area is, the smaller the area per inmate would be. This is due to the presence of common facilities at all prisons. It appears in Table 1 that this theory didn’t apply accurately in USA and Canada. Variations in standards between the respective geographical regions should be therefore taken under consideration.

The design and planning of Abu Dhabi prisons was based on United Kingdom standards, suitably adapted to local conditions.

Table 2 shows the three existing prisons in Abu Dhabi and the proposed Central prison project.

Table 2. Analysis of Prisons in Abu Dhabi

Al Ain is considerably smaller than Al Wathba and Al Sadar; consequently its floor area per inmate is higher. The number of inmates has increased markedly in the last 15 years. As Figure 4 shows, in 1995 the actual inmate population in Al-Wathba prison was more than 400% of the design capacity. Al-Ain prison population increased 382% and Al-Sadar population reached 200% of the actual design capacity. (Murray Ward & Partners and Ministry of P. W, 1995)

The design is meant to be a prototype to be replicated in different Emirates. Analysis of floor area per inmate showed that there is a large difference between the international standards and the proposed design. In Table 2 the different areas per inmate for the different prisons in UAE is illustrated. The figure shows the large difference between the floor area per inmate in existing prisons and the proposed air-conditioned one.

Heating at night as well as cooling load during the day are considered and calculated in the new proposal. This leads to the conclusion that there was no or little attempt to use passive energy means such as the use of thermal mass, or night cooling.

The cooling loads for the proposed central prison are assumed to be 4MW with 2 MW for heating load. This will add up to a total of 230 KWH/m². The estimated prison population for the Emirates of Abu Dhabi is approximately 5000 prisoners. Table 1 shows that the international standard for average floor area per inmate is 38m². According to the proposed design the total energy required to provide air-conditioning to all prisoners in the Emirates of Abu Dhabi should therefore be 43.7 GWH, an approximately 0.6% of the total energy consumption in the Emirates of Abu Dhabi. As previously indicated, a building envelope in hot climate region can be responsible for 40% of such energy consumption (Figure 5). For prisons, this could be as much as 0.24% of the total electric consumption in Abu Dhabi.

Table 2. Analysis of Prisons in Abu Dhabi

The feasibility study that was made for the project of the Central Prison indicates that the building was designed for 1200 inmate.
The building industry is a major sector for energy consumption in the Emirates of Abu Dhabi. The energy consumption is not only limited to the direct cost of air conditioning but also to the indirect cost and infrastructure required. In the developed world, buildings are responsible to as much as 50% of the total energy consumption (Harris, Elkadi, and Wigginton 1998). In the Emirates, this ratio can be much higher. This paper shows that 44% of the total electric consumption is a direct result of air-conditioning and other direct uses in buildings (e.g. lighting and water heating). As a result of the hostile climatic conditions in the Gulf area, the building envelope has a major contribution to the energy requirement for air conditioning. Elkadi et al (1999) showed that the building’s envelope contributes to as much as 40% of the energy required in buildings. In the light of the new policy to increase comfort among prison population, the role of the skin can be crucial for the total energy consumption. Prison façades have specific design characteristics. This paper reviewed the development of prisons’ façade design and the relation to environmental conditions. The paper also reviewed the development of prison design in UAE. Using expected energy consumption per inmate, and the expected increase in floor areas in relation to increasing prison population and increase in comfort conditions, the paper calculated the expected total energy requirements for air conditioning. An amount of 43.7 GWH is expected if the policy of providing air-conditioning to all prison buildings to be implemented. This constitutes a 0.6 percent of the total annual electric consumption in Abu Dhabi. The role of the prison’s envelope can therefore be as much as 0.24%. (Yik et al, 1998) show that appropriate design of the façade can reduce this amount by as much as 30%. An approximate figure between 1.75 and 5.24 GWH can be saved if the thermal efficiency of the façade is increased by 10 – 30% respectively. Such reduction can have tangible advantages not only on the Ministry of Interior’s budget for implementing this policy but also on the total Abu Dhabi electric production and electric infrastructure. The savings can also positively contribute to substantial reduction in CO2 emissions.

REFERENCES:

Elkadi, H., T. J. Wiltshire & S. Al Nahyan. (1999) Importance of peak hour building energy data on energy conservation Africa energy and environment, conference proceeding, Port Elizabeth, South Africa.


Figure 5. Skin role in Electric Consumption