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Suitability of sunken courtyards in the desert climate of Kuwait

Adil A. Al-Mumin*

Department of Architecture, College of Engineering and Petroleum, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait

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Abstract

The paper discusses the suitability of the sunken courtyard concept in the desert climate using Kuwait as a case study. It investigates three issues related to the concept: its ability to modify the harsh climate and to reduce the energy consumption, its construction costs compared to aboveground building, and the occupants' attitude towards living underground. The results are shown to be all positive and will be significant to the policy-makers, designers, and homeowners. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Subterranean dwellings exemplify man's struggle to survive and shelter himself against stressful climates and to achieve safe and comfortable living environment. For centuries these indigenous designs have been used by residents in the arid regions of North Africa such as Matmata in southern Tunisia, the Goreme Valley of Cappadocia in central Turkey, the Province of Henan, Shanxi, and Gansu in northern and others, some of which date back 5000 years [1].

Among the various types of subterranean dwellings one type is very common. It is a vertical design of a deep patio open to the sky and surrounded by walls and rooms, called pit or a courtyard/patio dwelling. The sunken courtyard building, as it will be referred to throughout this paper, is an underground structure that closely follows the introverted design of the famous traditional aboveground courtyard building. In addition to its ability to create a pleasant microclimate, both provide the privacy, safety, and social unity needed in these conservative societies. Underground dwellings add extra protection against climate, and their maintenance costs are usually less expensive than aboveground dwellings of the same sizes. For these reasons, several researchers have recommended its implementation and assured its sustainability in the harsh climate worldwide [2,3] and Kuwait in particular [4,5].

However, there has been lack of studies that quantitatively measure the acclaimed benefits in energy and economic as well as the occupants' attitudes and satisfaction expected from this concept, especially in the desert climate of Kuwait. Such information is vital for the policy-makers to seriously consider adopting this new/old concept. This paper investigates these three areas quantitatively and provides new and significant conclusions suitable to this part of the world.

2. Examples of worldwide sunken courtyards

2.1. Vernacular dwellings

The shape, size, and other design details of a vernacular sunken courtyard dwelling vary between regions and even among households in the same region depending on the socio-cultural background, financial standard, and environmental features such as geomorphological configurations, soil type, climatic pattern, and hydrological systems. However, the overall basic design remains similar. The following discussion is based on surveys of vernacular sunken courtyard dwellings in Tunisia and China as reported by Golany [6–8].

In Matmata, southern Tunisia, the pit (which emulates the courtyard) is usually semi-circular in shape ranging from 5 to 10 m in diameters with a depth measuring about 10 m from the ground level to the floor of the open courtyard (Fig. 1a). In China, the pit is either square or rectangular with typical dimensions of approximately 9 to 13 m and a depth of approximately 9 m (Fig. 1b). In Bulla Regia, northern Tunisia, archeological settlements of the Romans were uncovered showing consistent use of the sunken courtyard concept. The courtyard widths are similar to those in Matmata, but the depth is only about 5 m.

* Assistant Professor
E-mail address: almumin@yahoo.com (A.A. Al-Mumin).

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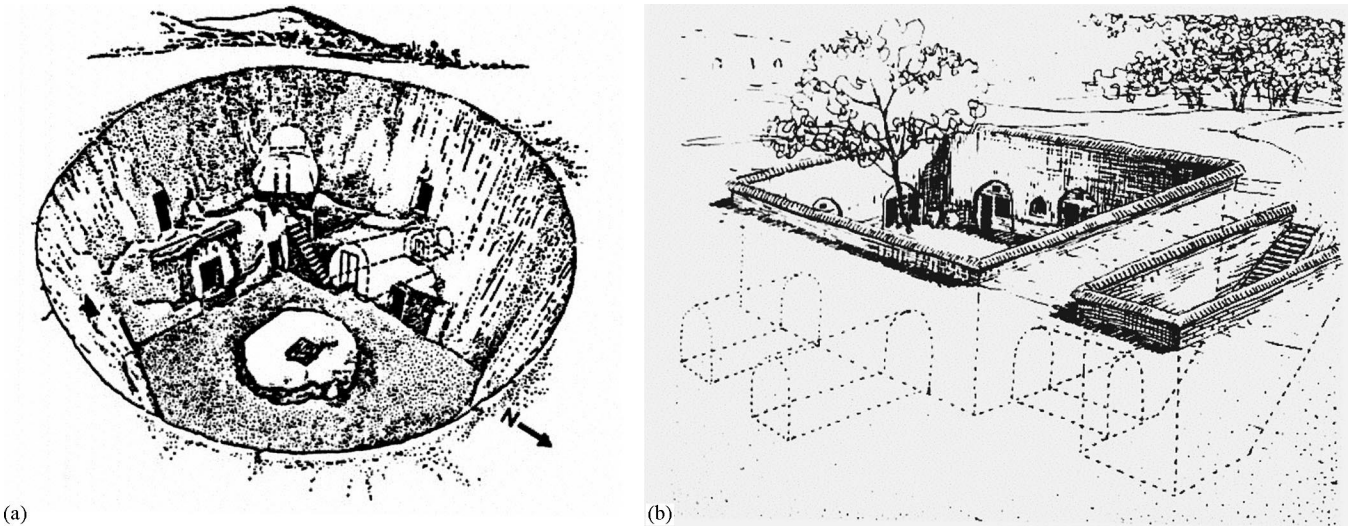


(a) (b)

Fig. 1. (a) Vernacular sunken courtyard in Matmata, Tunisia [6]; (b) Vernacular sunken courtyard in Matmata, Tunisia [8].

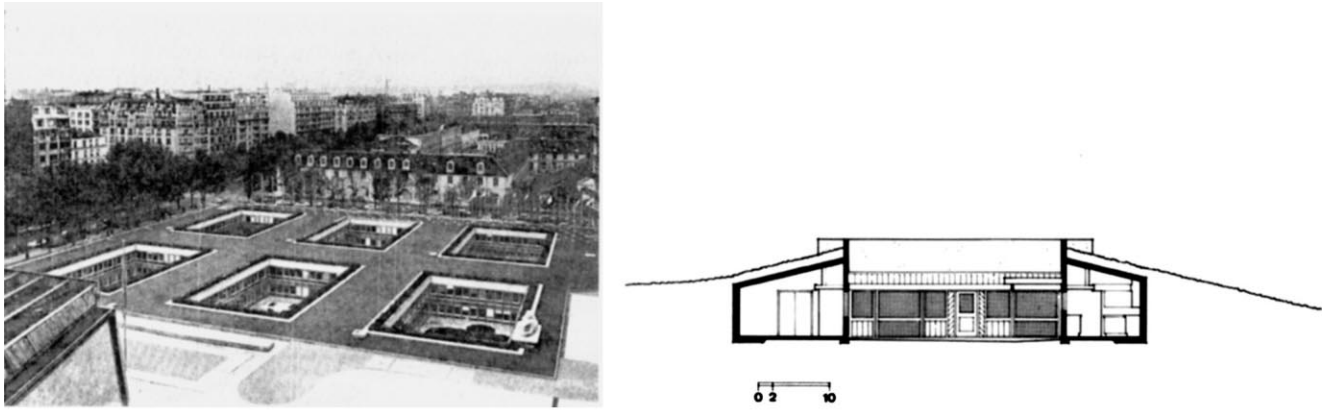
The entrance usually consists of stairways or graded tunnels leading to the interior courtyard with L-shaped corridor to insure privacy. The vernacular rooms in sunken courtyards are usually scooped out from the courtyard surfaces, and are usually long and narrow in the lower level, and smaller in the upper level (if the soil strength permits). The ceiling are usually vaulted to accommodate daylighting and ventilation needs. The typical dimensions of the rooms in Matmata are 4–5 m wide and 8–10 m long with a height of about 3 m for the large rooms, and between 3–4 m wide and 4–5 m long with a height of 2–5 m for the smaller ones. Similar room dimensions are found in Bulla Regia. The rooms in the Chinese dwellings are generally smaller with average dimensions of 3 m × 7 m and a height of 3 m.

The soil cover from the ground level to the room ceiling in Matmata ranges from 6–7 m and in China it ranges from 3–4 m. Such thickness eliminates any potential for water leakage caused by possible heavy rainfall and it significantly reduces the heat gain and the heat loss rates into and out of the building.

2.2. Contemporary buildings

Since the 1940s, underground building constructions have been adopted in contemporary building designs all over the world for various purposes ranging from defence to preservation of landscape [9]. The concept of using underground buildings received more widespread attention after the energy crisis in 1973 primarily due to its suitability as a climate control strategy and to the subsequent energy savings it provides, among others. Housing and military installations have been popular in the United States; shopping centers in Japan and Stockholm; oil storage spaces in Norway and Sweden; and parking spaces, theatres, libraries, and other examples of public and private underground buildings can be seen throughout the world [10].

Examples of contemporary sunken courtyards can be found in large scale projects such as the UNESCO buildings in Paris (Fig. 2a), the undergraduate library at the university of Illinois, the state capital of Texas at Austin, and the expansion of the Louvre museum in Paris, France. Also, they



(a) (b)

Fig. 2. (a) UNESCO building, Paris; (b) Bordie house [3].