The Role of Gardens and Water Pools in Central Courtyards and their Impacts on Daylighting in Selected Historical Houses Qajar Era in Kashan

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Extended Abstract

Introduction

Kashan, a city situated at an elevation of 982.3 meters, is renowned for its historical Qajar-era houses, which embody the evolved concept of "home" in Iranian architecture. In the past, daylight served as the primary source of illumination and constituted a fundamental element in the architectural design of these residences. The central courtyards—ranging from single to multiple in number—played a crucial role in providing natural lighting for these houses. Acting as conduits for daylight, these courtyards exhibited considerable diversity in geometry, proportions, and materials, including features such as water pools and garden plots. Multiple factors, including form, proportion, geometry, and the materials used for courtyard walls and flooring, influenced the optimization of daylight penetration, notably the light reflectance properties of these materials. This research investigates the relationship between water pools and garden plots as well as the utilization of natural light in eight historical houses of Kashan. The study evaluates the climatic performance of central courtyards as well as their daylight-channeling capacity through theoretical analysis and proportional relations. It aims to determine the correlation between the size of pools and gardens with the degree of light distribution and climatic performance, thereby identifying the role of these elements in supplying and directing daylight into the spaces adjacent to the central courtyard.

Methodology

This research adopted a quantitative approach along with a descriptive research method, combining the review of library sources with the analysis of field observations and measurements. This study was conducted in three stages:

Stage 1. Literature Review: at this stage, the key parameters influencing daylight performance were identified; these parameters included the daylight factor (DF) and the section aspect ratio (SAR), both of which were associated with the ability of central courtyards to channel natural light. In addition, physical comfort parameters such as PAR and R_1, which indicated the climatic qualities of central courtyards, were introduced.

Stage 2 . Case Selection and Field Survey: eight historical houses in Kashan were selected based on criteria such as structural integrity, accessibility for field documentation, minimal alterations (caused by the passage of time or inappropriate restorations), and the representation of courtyard typologies (single-, double-, triple-, and multi-courtyard houses). At this stage, existing architectural plans were verified and completed through field surveys, and precise, digital three-dimensional models were produced to ensure an accurate understanding of the number of courtyards, their dimensions, and spatial characteristics.

Stage 3. Data Analysis: the geometric and proportional performance of central courtyards was evaluated, using the SAR index to assess daylight reception. However, the climatic performance was examined through the PAR and R_1 indices, taking into account the specific climatic conditions of the region. Subsequently, the combined surface area of garden plots and water pools was compared with the total courtyard floor area. These values were, then, analyzed alongside daylighting and climatic performance data to establish logical proportional relations.

It is worth noting that by assessing the climatic performance of the central courtyard, this study not only highlights the role of water pools and garden plots in environmental regulation but also emphasizes the importance of daylight as a determining factor in the inclusion as well as functional significance of these elements in the courtyard design.

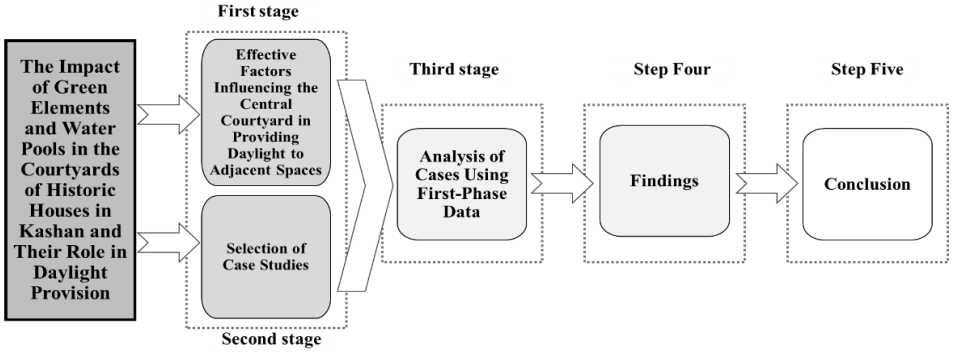

Chart 1: Research stages

Findings

The collected data were compared and analyzed to enhance the understanding of the research outcomes. The section aspect ratio (SAR), which indicated the daylight-channeling performance of the central courtyard for adjacent spaces, was calculated alongside the climatic indices PAR and R_1, which evaluated the environmental performance of each house. The results showed that SAR values in some houses exceeded the recommended standards (SAR $\geq$ 1 for square-shaped courtyards and SAR $\geq$ 2 for rectangular courtyards). In contrast, in others, they fell below these thresholds. Similarly, the climatic performance indices in most cases conformed to the recommended ranges ($0.3 \leq PAR \leq 1$ and $0.4 \leq R_1 \leq 8$). Exceptions were observed in courtyard y_1 of the Āl-e Yāsīn House, and courtyards y and y_1 of the Borujerdi and Tabātabāei Houses, where the R_1 ratio was within the acceptable range, but the PAR index did not meet the recommended standards. In addition, the ratio of the combined surface area of garden plots and water pools to the total courtyard area varied considerably across the selected houses, ranging from a minimum of 8.6% to a maximum of 56%. When comparing these ratios with the PAR index, it was found that courtyards with substandard PAR values had garden-and-pool ratios between 17.5% and 37%. In contrast, the ratio ranged from 7% to 56% in courtyards with adequate climatic performance. This suggests that, within the studied samples, no consistent or direct correlation exists between the climatic performance of courtyards and the extent of garden and pool coverage. According to the SAR analysis, most houses provided sufficient daylight access to spaces adjacent to the central courtyard, except in a few cases where the SAR was below the recommended level. The courtyard floors were primarily covered with brick (10–15% reflectance), water pools (35–45% reflectance), and garden plots (25–40% reflectance). A key finding was that the ratio of garden and pool area to the total courtyard surface demonstrating an inverse relationship with daylight-channeling performance: courtyards with adequate daylight-channeling (standard SAR); the combined ratio of garden and pool areas was less than 20%. In courtyards with inadequate daylight-channeling (low SAR), the ratio exceeded 20%; in some cases, it reached 56%. In conclusion, houses with standard SAR values typically incorporated larger brick-paved surfaces with lower reflectance and allocated less area to gardens and pools. Conversely, houses with lower SAR values exhibited greater coverage by reflective surfaces such as garden plots and water pools.

Conclusion

The findings of this study reveal that in the examined historic houses of Kashan, the inadequate geometric configuration and proportions of central courtyards in channeling daylight to adjacent spaces were compensated through the use of courtyard flooring materials with higher light reflectance, particularly water pools and garden plots. Accordingly, the results of this research should be carefully considered in the restoration and revitalization of these residences, as well as other historical houses of Kashan, which, in the recent decades, have gained increasing attention due to the expansion of tourism industry. Such efforts require particular attention to the existing architectural components and elements—such as pools,

green spaces, and other structural features—whose functional and cultural significance extend beyond their aesthetic value. These houses represent a valuable legacy of domestic architecture in Iran, offering insight into the traditional application of simple yet effective strategies for harnessing natural daylight. Recognizing and preserving these approaches can provide meaningful lessons and serve as a model for contemporary housing design.

Keywords: central courtyard, garden plot, historical houses, Kashan, natural daylighting, water pool.