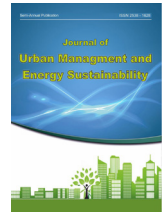


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CASE STUDY RESEARCH PAPER

Evaluating the Climatic Role of the Howzkhaneh in the Architectural Body of Historic Houses: A Case Study of the Mosaver-ol-Maleki House, Isfahan

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ABSTRACT

In the hot-arid architecture of the Iranian plateau, water is not merely a decorative motif but an active environmental device, and the howzkhaneh is the space in which this role is most concentrated. This study evaluates, with a climatic approach, the extent to which the water body of the howzkhaneh modifies the summer microclimate within the architectural body of a Qajar-era courtyard house, taking the Mosaver-ol-Maleki house in Isfahan as a case study. The functional-climatic level of an embedded, qualitatively-dominant mixed-methods design is operationalised through three complementary tools: a psychrometric estimation of the evaporative-cooling potential for the July design day of Isfahan; conceptual air-circulation schematics coupling the pool, the sash windows and the roof skylight; and a two-dimensional natural-convection field validated against the de Vahl Davis benchmark ($Ra = 10^4$, $|v|_{\max} \approx 5.07$). The wet-bulb temperature of the base state is only 20.1°C , giving a theoretical temperature-depression ceiling of 16.9°C ; for the realistic efficiency band of a still pool the attainable depression in the immediate microclimate of the water is about $2-7^\circ\text{C}$, and it falls below 10°C as the inlet humidity approaches 50%. The convection field confirms a closed, stack-driven circulation cell. It is concluded that water here operates not as an isolated element but as part of an integrated climatic system, pool, level difference, skylight and openings whose cooling value is realised only when airflow transports it to the living spaces, reframing the howzkhaneh as a climate-responsive component of the architectural body.

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INTRODUCTION

Across the Iranian plateau, where a hot and dry climate and chronic water scarcity have shaped settlement for millennia, water acquired a status that far exceeds its utilitarian value. In Persian thought water is at once a vital necessity, a symbol of purity and life, and a formal ordering device of architecture and the garden; its careful, purposeful presence became a defining feature of Iranian building culture (Laureano, 2001; Soltanzadeh, 2017). The long tradition of subterranean water engineering the qanat and, in Isfahan, the interconnected madi canals fed by the Zayandeh-rud supplied the courtyards, gardens and houses of the historic city and, in doing so, tied the domestic interior to a city-scale hydraulic infrastructure (Roaf, 2003; Ikemoto et al., 2021). The introverted courtyard house is the architectural type in which this water culture and the climatic imperatives of the hot-arid zone are most tightly fused. A substantial body of building-science research has established that the central courtyard is an effective microclimate modifier whose orientation, proportion and dimensions govern shading, night-sky radiative cooling and the diurnal exchange of warm and cool air (Soflaei et al., 2016, 2017; Taleghani et al., 2014; Zamani et al., 2018). Alongside the courtyard, the vernacular repertoire of passive cooling in Iran includes the windcatcher (badgir), the shaded portico, the semi-sunken summer room and the cistern, each of which has been documented and, increasingly, quantified (Bahadori, 1978; Saadatian et al., 2012; Najaf & Yaghoubi, 2015; Ghobadian, 1998). Within this repertoire, evaporative cooling from open water is the mechanism most directly dependent on the very dryness that makes the summer uncomfortable. Because the cooling limit of an air stream is set by its wet-bulb temperature, the extremely low summer humidity of the central plateau endows still and moving water with a large latent-cooling potential (Givoni, 1994; Watson & Labs, 1983; Cuce & Riffat, 2016). The howzkhaneh a covered, often semi-sunken pool-room placed at the heart of the aristocratic house, with a

central pool beneath a roof skylight concentrates this mechanism: it combines a permanent water surface, a level difference that stabilises a pool of cool air, and a top opening that drives stack ventilation (Haji-Ghasemi, 1998; Pirnia, 2004; Haeri Mazandarani, 2009).

Despite the centrality of the howzkhaneh in the Qajar house of Isfahan and Shiraz, most of the existing literature treats it descriptively as a decorated ceremonial space or subsumes it within general accounts of the courtyard and the windcatcher. Quantitative, climate-focused evaluation of the water body itself, as an environmental device operating within the architectural body, remains scarce. The purpose of the present study is to help close that gap. Taking the Mosaver-ol-Maleki house in Isfahan a nationally registered Qajar house in which water is present both at courtyard level and in the depth of the building (an octagonal pool in a two-storey, cross-shaped howzkhaneh beneath a skylight) as a case study, the paper asks: to what extent, and by what physical mechanism, does the water of the howzkhaneh modify the summer microclimate of the house? To answer this question with a defensible, reproducible evidence base while remaining explicit about the limits of the analysis, the study operationalises the functional-climatic level of the broader research framework through three complementary tools. First, classical thermodynamics is used to establish the theoretical ceiling of evaporative cooling for the Isfahan design day, independent of any numerical model. Second, conceptual air-circulation schematics make explicit the causal chain from evaporation to transport. Third, a validated two-dimensional natural-convection field, benchmarked against the canonical de Vahl Davis solution (De Vahl Davis, 1983) reveals the qualitative structure of buoyancy-driven flow in an enclosed space with a thermal gradient. Throughout, the paper is explicit that these tools bound and explain, but do not replace, a full three-dimensional computational fluid dynamics (CFD) solution of the real building, which is identified as the necessary

next step. The contribution is thus twofold: a transparent quantification of the climatic ceiling and mechanism of the howzkhaneh's water in a real Qajar house, and a methodological template that couples psychrometrics, conceptual flow analysis and a validated convection benchmark before, and in support of, resource-intensive 3-D CFD.

MATERIALS AND METHODS

The case study: The Mosaver-ol-Maleki house
The Haj Mosaver-ol-Maleki house is one of the distinguished historic houses of Isfahan, located in the Now (New) quarter. It is named after its owner and builder, Mohammad-Hossein Mosaver-ol-Maleki, a celebrated Isfahani painter and poet, and is registered on the National Heritage List. From the standpoint of the present study the

house is an exceptional specimen because water is present both at courtyard level (the central courtyard pool) and in the depth of the building (the octagonal pool of the two-storey, cross-shaped howzkhaneh beneath a rose-coloured skylight), establishing a direct link between the element of water, the built body and the microclimate (Tab. 1 and Fig. 1). The introverted organisation a rectangular central courtyard with a pool on its axis, the principal talar/shah-neshin on one side, and a semi-sunken, double-height howzkhaneh coupled to both courtyard and talar, brings light, water and ventilation together in a single spatial focus (Tab. 2). The section drawings reveal the level difference between the howzkhaneh and the courtyard and the double height of the shah-neshin, both of which participate in the displacement of warm and cool air.



Figure 1: Mosaver-ol-Maleki historical house plan and photos (Source: Archive)

Table 1: Identity of the case study - the Mosaver-ol-Maleki house

Attribute	Description
Name & owner	Haj Mosaver-ol-Maleki house; attributed to Mohammad-Hossein Mosaver-ol-Maleki (Isfahani painter and poet)
City / quarter	Isfahan, Now (New) quarter (Taleghani St. / Kashani-Mirdamad axis)
Period	Safavid/late-Zand core; ornament and howzkhaneh of the Qajar period
National registra-tion	21 September 1974 – registration no. 991
Current use	House-museum of handicrafts
Spatial organisa-tion	Rectangular central courtyard with a rectangular pool; rooms on four sides; two-storey talar/shah-neshin with corner rooms; cross-shaped two-storey howzkhaneh
Water elements	Octagonal howzkhaneh pool beneath the skylight; large stone courtyard pool facing the talar; water inflow/outflow route
Notable orna-ment	Stucco and muqarnas, mirror-work, sash windows (orosi) with coloured glass, latticed skylight, wall paint-ing

The dimensional data required for numerical modelling are summarised in Table 2. In keeping with a conservative treatment of evidence, dimensional items derived from the measured survey are flagged as coming from the surveyed

AutoCAD drawings, so that unverified figures do not enter the quantitative analysis; the free water-surface area, the key driver of evaporation, is identified as the decisive geometric variable. (Tab. 2).

Table 2: Geometric characteristics of the courtyard, howzkhaneh and pools (to be scaled from the surveyed AutoCAD drawings).

Component	Central courtyard	Howzkhaneh	Pools
Geometric form	Rectangle (elongated N-S)	Cross-shaped (two storeys)	Courtyard pool: rectangle; howzkhaneh pool: octagon
Length × width (m)	≈ 12–18 × 8–12	Talar span ≈ 5–8	Courtyard pool ≈ 3–6 × 2–3; octa-gon ≈ 2–3 dia.
Height / depth (m)	Wall ≈ 4–8 (one/two storeys)	Two storeys; sunken level diff. ≈ 1–1.5	Water depth ≈ 0.3–0.5
Length-to-width ratio	≈ 1.6 (from plan)	≈ symmetric cross plan	Courtyard pool ≈ 1.5–2; octa-gon ≈ 1 (regular)
Free water-surface area (m ²)	—	—	Key evaporation variable: court-yard ≈ 6–18; howz-khaneh ≈ 3–7
Orientation	Longitudinal N-S axis; relative to prevailing W/SW wind	Cross axis aligned with court-yard	Co-axial with the courtyard's longitudinal axis
Openings	Sash windows and doors facing the courtyard	Roof skylight + lateral open-ings to courtyard/talar	Water inlet/outlet (channel and overflow)

Climatic context of Isfahan city

Under the Köppen classification, Isfahan lies in the cold desert (BWk) zone: hot and very dry summers, cold dry winters, scant annual precipitation and a large diurnal temperature range. The hottest month is July, with mean daily temperatures near 30 °C, mean maxima of about 36–37 °C and absolute maxima above 40 °C; the annual precipitation is very low (~120–135 mm) and effectively zero from July to September. Relative humidity falls to its summer minimum of roughly 23–25% in July and August. Prevailing summer winds are broadly from the west to south-west, and the clear sky gives 11–11.5 hours of sunshine per day. This coincidence of high temperature, very low humidity and intense radiation is precisely the condition under which water-based passive cooling is most

effective, because hot, dry air has the greatest capacity to absorb water vapour and thereby lower its sensible temperature. Accordingly, the July design day is taken as the critical thermal condition and the base state for all calculations (Tab. 3).

Simulation framework and boundary conditions

The full quantitative answer to the research question requires a CFD simulation of airflow and heat-and-moisture transport, which yields the spatial fields of velocity, temperature and humidity in the real volume of the building. In this study the CFD stage is framed with the Design Builder environment widely used for natural ventilation and microclimate studies of courtyard houses—using a standard k-ε turbulence model, first-order Upwind discretisation for

stability, and residual monitoring (particularly continuity) for convergence (Tabs. 3 and 4). Validation follows standard practice: field measurements of air speed at key points (notably the howzkhaneh and the rooms adjoining the pool) are taken with a hot-wire anemometer at a reference height of about 1.7 m over several times of day during a representative summer period, and the same points are reproduced numerically; agreement to within about 10% relative error is required (comparable studies report 7–9%). The

methodological decision of central importance is the representation of water: the pool surfaces are defined as evaporative cooling boundaries whose near-equilibrium surface temperature and moisture flux both lower the sensible temperature and raise the humidity of the adjacent air, whereas in the control scenarios the same surfaces are set as dry (non-evaporating) so that the difference between the two states isolates the net effect of water.

Table 3: Simulation input and boundary conditions (Isfahan July design day).

Parameter	Base value	Source / note
Outdoor air temperature	≈ 36–37 °C (July maximum)	Isfahan normal / EPW
Relative humidity	≈ 23–25%	Summer minimum
Wind speed	from station (to be finalised)	EPW / Isfahan synoptic
Wind direction	fixed (for scenario comparability)	prevailing W–SW
Water-surface temperature	from survey / equilibrium assumption	evaporative boundary

Table 4: Key CFD numerical solver settings (template, to be updated with run values).

Parameter	Base value	Note
Turbulence model	Standard k–ε	Suitable for internal/semi-open flows; stable and widely used
Discretisation scheme	Upwind (first order)	High stability against numerical oscillation
Outer iterations	500 (max.)	Until convergence
Pressure iterations	9	Accuracy and reduced instability
Continuity residual	1×10^{-5}	Mass-conservation convergence criterion
Inner KE/ε iterations	6	Control of turbulence dissipation rate
Relaxation factor	1.0	Reduce if unstable
Mesh	Refined near water/openings	Higher density in high-gradient zones; grid-independence test

Table 5: Base climatic conditions for the cooling estimation (Isfahan July design day).

Parameter	Value	Note
Dry-bulb temperature	37 °C	July mean maximum
Relative humidity	23%	Summer minimum
Atmospheric pressure	83.8 kPa	Elevation ≈ 1575 m

Methodology

To estimate the cooling potential, the thermodynamic properties of air in the base state are computed with standard psychrometric relations. The saturation vapour pressure is obtained from the Tetens equation, $e_s(T) = 0.6108 \cdot \exp(17.27 \cdot T / (T + 237.3))$ [kPa],

the actual vapour pressure from $e = (RH/100) \cdot e_s(T_{db})$, and the humidity ratio (mass of vapour per mass of dry air) from

$$W = 0.62198 \cdot e / (P - e).$$

The dew-point temperature is obtained from

the inverse of the Tetens relation and the wet-bulb temperature from a numerical (bisection) solution of the psychrometric wet-bulb equation between the dew-point and the dry-bulb temperatures. The moist-air enthalpy is

$$h = 1.006 \cdot T + W \cdot (2501 + 1.86 \cdot T) \text{ [kJ/kg]}.$$

Finally, the evaporative-cooling efficiency ε is the ratio of the actual to the maximum possible temperature depression, so that the outlet air temperature for a given efficiency is

$$T_{\text{out}} = T_{\text{db}} - \varepsilon \cdot (T_{\text{db}} - T_{\text{wb}}).$$

Because a still pool is not a saturated cooling pad, its realistic efficiency is a fraction of unity; the calculation therefore reports the achievable

temperature across a range of ε and, separately, the sensitivity of the theoretical ceiling to inlet humidity (ASHRAE, 2017; Givoni, 1994).

FINDINGS AND DISCUSSION

Thermodynamic properties of the outdoor air
Applying the psychrometric relations to the base state (37 °C, 23% relative humidity, 83.8 kPa) yields the properties collected in Table 6. The single most important result is that the wet-bulb temperature is only about 20.1 °C; the theoretical ceiling of temperature depression under these conditions is therefore about 16.9 °C. In other words, the extreme summer dryness of Isfahan endows the air with an unusually large latent-cooling reservoir, which is exactly the physical basis on which the water architecture of the city was elaborated. (Tab. 6).

Table 6: Thermodynamic properties of the outdoor air at the base state (37 °C, 23% RH, 83.8 kPa).

Quantity	Computed value
Saturation vapour pressure at 37 °C (es)	6.275 kPa
Actual vapour pressure (e)	1.443 kPa
Humidity ratio (W)	10.9 g/kg
Dew-point temperature (Td)	12.4 °C
Wet-bulb temperature (Twb)	20.1 °C
Enthalpy (h)	65.2 kJ/kg
Theoretical depression ceiling (Tdb – Twb)	16.9 °C

Cooling potential and efficiency

Because a calm pool is not a saturated evaporative pad, the actual temperature depression it produces is a fraction of the theoretical ceiling. Figure 2 plots the achievable air temperature against cooling efficiency, and Table 7 lists the same values together with the corresponding outlet relative humidity. Within the realistic band for a still pool ($\varepsilon \approx 10\text{--}40\%$), the temperature depression in the immediate microclimate of the water is about 2–7 °C, a drop that, in the enclosed volume of the howzkhaneh and at the level close to the water surface, is both perceptible and effective. At a representative efficiency of 30% the outlet air reaches about 31.9 °C, a depression of roughly 5 °C that, combined with the

accompanying rise in humidity and with shade, produces a tangible sense of comfort. (Fig. 2)

Sensitivity to air humidity

The cooling potential depends strongly on the dryness of the incoming air. Figure 3 and Table 8 show that as the inlet relative humidity rises from 23% to 50%, the theoretical depression ceiling collapses from about 17 °C to below 10 °C. This result underlines why the water architecture of Isfahan is so highly developed: the same oppressive dryness that characterises the plateau summer is the necessary condition for effective evaporative cooling. The howzkhaneh, in short, converts a climatic liability extreme aridity into the resource that cools the heart of

the house. (Fig. 3)

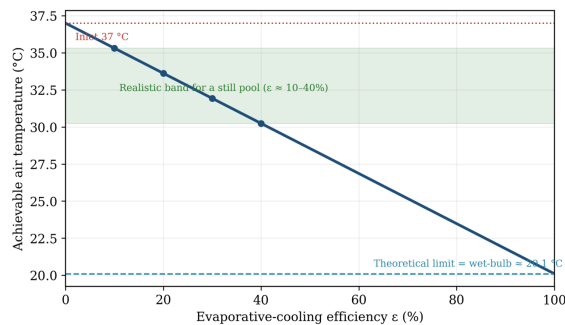


Figure 2: Achievable air temperature as a function of evaporative-cooling efficiency for the base state; the shaded band marks the realistic efficiency range of a still pool.

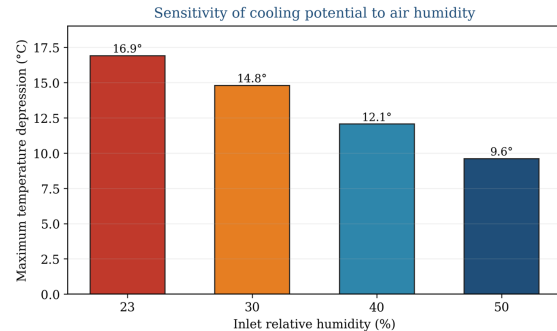


Figure 3: Sensitivity of the maximum temperature depression to inlet relative humidity at 37 °C.

Table 8: Sensitivity of the cooling potential to inlet relative humidity (dry-bulb 37 °C).

Relative humidity (%)	Wet-bulb temperature (°C)	Depression ceiling (°C)
23	20.1	16.9
30	22.2	14.8
40	24.9	12.1
50	27.4	9.6

Transparency of the calculation

For full reproducibility, the calculation path for the base state (37 °C, 23%, 83.8 kPa) is given step by step; a reader may repeat it for any other condition:

$$e_s(37) = 0.6108 \cdot \exp(17.27 \cdot 37 / (37 + 237.3)) = 6.275 \text{ kPa}$$

$$e = 0.23 \cdot 6.275 = 1.443 \text{ kPa}$$

$$W = 0.62198 \cdot 1.443 / (83.78 - 1.443) = 0.0109 \text{ kg/kg} = 10.9 \text{ g/kg}$$

$$T_d = 237.3 \cdot \ln(e/0.6108) / (17.27 - \ln(e/0.6108)) = 12.4 \text{ °C}$$

$$T_{wb} = 20.1 \text{ °C}$$

$$\Delta T_{\max} = T_{db} - T_{wb} = 37 - 20.1 = 16.9 \text{ °C}$$

$$T_{\text{out}}(\varepsilon = 0.3) = 37 - 0.3 \cdot 16.9 = 31.9 \text{ °C}$$

Thus, in the best theoretical case the air could be cooled to 20.1 °C, but at the realistic efficiency of about 30% for a still pool the microclimate near the water reaches roughly 32 °C a depression of about 5 °C that, together with increased humidity and shade, yields a perceptible improvement in comfort. Figure 3 traces this process on the psychrometric chart: the red point is the out-

door state (37 °C, 23%), the blue point the saturation (wet-bulb) limit at 20.1 °C, and the orange diamond the realistic outlet at $\varepsilon \approx 30\%$ ($\approx 32 \text{ °C}$); the dashed path represents the movement of the air state towards lower temperature and higher humidity. This is the only figure whose basis is an actual numerical calculation; it is nonetheless not CFD, because it does not show the spatial distribution of these changes. (Fig. 4)

Conceptual mechanism of airflow and cooling

The psychrometric ceiling establishes what the water can do; the conceptual schematics establish how the architecture puts it to work. Figure 4 shows the principal mechanism of the how-zkhaneh in section: warm air becomes buoyant at the top of the space and escapes through the roof skylight (the stack effect); this outflow creates a suction that draws fresh air from the courtyard through the sash windows into the pool-house; the incoming air passes over the pool surface, gives up part of its sensible heat to evaporate water, and becomes cooler and more

humid air that collects at the lower level of the space. The psychrometric box on the section is a reminder of the theoretical ceiling (wet-bulb

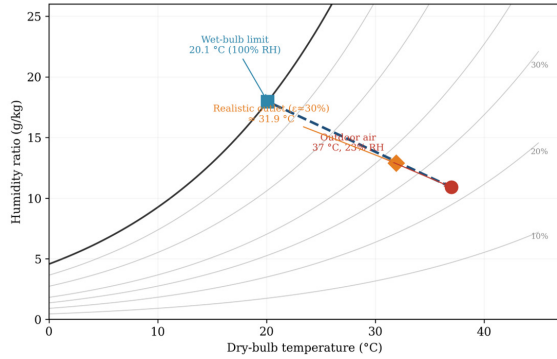


Figure 4: The evaporative-cooling process on the psychrometric chart: outdoor state, wet-bulb limit and realistic outlet ($\epsilon \approx 30\%$).

At plan level the prevailing wind and the pressure difference guide air from the courtyard towards the howzkhaneh. The air path runs over the courtyard pool (a pre-cooler) and, after passing through the sash windows, reaches the pool-house before being discharged on the far side. The schematic makes explicit that the placement of the pool in the path of the airflow, and its coupling to the openings, is the condition for transferring the cooling effect of the water to the living spaces: water alone is not sufficient; the airflow must carry its effect. (Fig. 6)

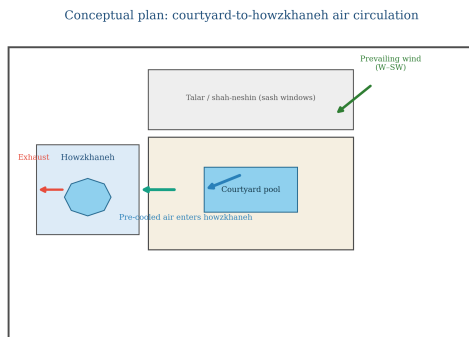


Figure 6: Conceptual plan of courtyard-to-howzkhaneh air circulation (schematic).

20.1 °C) and the realistic depression (3–7 °C). (Fig. 5)

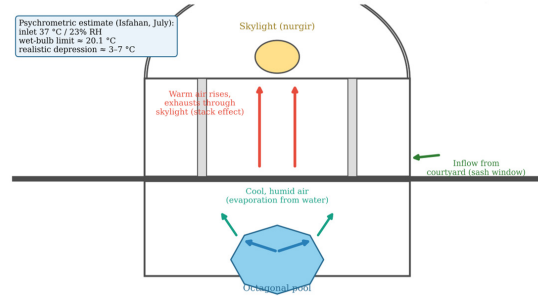


Figure 5: Conceptual section of the howzkhaneh showing the stack-driven airflow and evaporative cooling

Figure 7 illustrates qualitatively how temperature is lower near the water surface and rises with distance from the pool and with height in the space. It is emphasised that the colour distribution in this figure is idealised and illustrative, not the solution of the flow equations; its purpose is to give the reader a correct qualitative expectation of the real field from CFD. (Fig. 7)

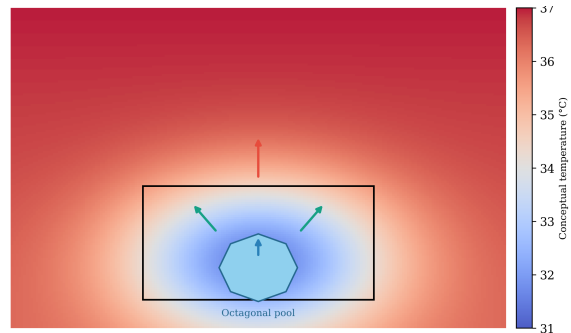


Figure 7: Conceptual (idealised) temperature field around the pool

Two-dimensional natural-convection field

To move from schematic expectation towards physical rigour, a two-dimensional Boussinesq natural-convection field was solved in the vorticity–stream-function formulation and validat-

ed against the canonical de Vahl Davis benchmark. At $Ra = 10^4$ the computed peak absolute stream function, $|\psi|_{\max} \approx 5.07$, reproduces the reference value, confirming the correctness of the solver (De Vahl Davis, 1983). Figure 8 presents the four key fields. In the solution, air rises along the warm wall, cools at the top of the space, descends along the cool wall and forms a closed circulation cell; the velocity is minimum at the centre and maximum near the walls (panels a and c). The temperature field and isotherms (panel b) show thermal stratification and the transfer of heat from the warm to the cool side, with the isotherms bending in the middle of the space the signature of convection dominating over conduction. The stream function (panel d) makes the single closed circulation cell explicit. This same pattern is the physical logic of air circulation in enclosed spaces that possess a temperature difference, such as the howzkhaneh. (Fig. 8)

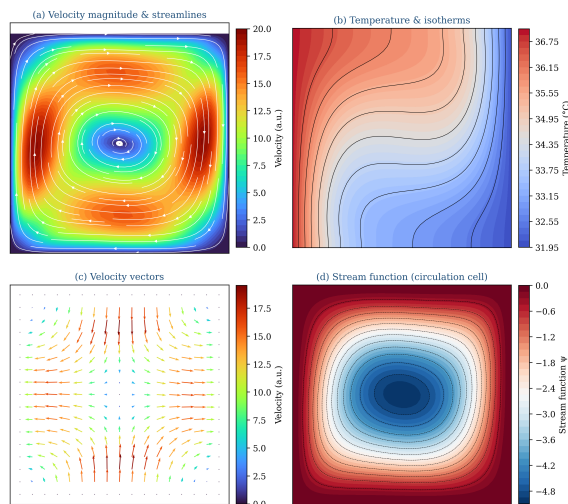


Figure 8: Two-dimensional natural-convection benchmark ($Ra = 10^4$, validated against de Vahl Davis, $|\psi|_{\max} \approx 5.07$): (a) velocity magnitude and streamlines; (b) temperature and isotherms; (c) velocity vectors; (d) stream function.

It must be stated plainly that this field is an educational, simplified two-dimensional model of buoyancy-driven convection in an enclosure,

not a three-dimensional CFD solution of the Mosaver-ol-Maleki house. Its role is to demonstrate rigorously and reproducibly the type and structure of the flow that the qualitative schematics assert, and to provide a validated physical reference against which the future 3-D simulation can be interpreted.

Interpretation for the Mosaver-ol-Maleki house

Taken together, the findings explain the special position of the water elements of the Mosaver-ol-Maleki house. The semi-sunken, covered howzkhaneh by virtue of its enclosure, its remove from direct radiation and its proximity to the water surface is the most favourable space for the accumulation of cool, humid air and is therefore the coolest focus of the house on hot summer days. The roof skylight, beyond its lighting and aesthetic role, acts as a thermal chimney: the escape of warm air through it creates the suction that sustains the ventilation cycle and, with it, the evaporation. The central octagonal pool is the source of evaporation and humidification, while the large courtyard pool acts as a pre-cooler for the air entering the surrounding spaces. The sash windows and openings facing the courtyard provide the path for the pre-cooled air and for the transfer of the water's effect to the rooms. In this way, water in this house is not an isolated decorative element but part of an integrated climatic system that works in concert with the geometry of space, the level difference, the skylight and the openings. This is precisely the 'role of water in the architectural body' that constitutes the central subject of the study. The key interpretive point is that the environmental value of the water's cooling is realised only when the airflow transports that effect from the surface of the pool to the living spaces. The psychrometric estimate also furnishes a clear physical expectation for each of the intended simulation scenarios (Tab. 9). These are directional hypotheses, not numerical results; the CFD stage is to test them, and all of them are bounded above by the theoretical depres-

sion ceiling of 16.9 °C. The comparison of the full-water (S1) and dry (S2) states is designed to measure the net effect of water directly, while

the remaining scenarios probe the sensitivity of that effect to water-surface area, to the skylight, and to the configuration of the openings.

Table 9: Simulation scenario matrix (S1–S6) and psychrometry-based expectations

Code	Scenario focus	Psychrometry-based expectation
S1	Baseline (full pool)	Temperature depression and humidity rise at howzkhaneh level relative to outdoor air; the reference microclimate
S2	Dry pool (control)	Temperature returns close to outdoor and minimum humidity; the S1–S2 difference isolates the net effect of water
S3	Reduced water-surface area	Smaller depression than S1 owing to a lower evaporation rate
S4	Increased surface / fountain	Closer approach to the wet-bulb limit; greatest depression among the scenarios
S5	Skylight open / closed	Open: warm-air exhaust and sustained evaporation give a larger depression; closed: heat accumulates
S6	Opening configuration	Determines the degree of transfer of cool, humid air from the howzkhaneh to the living spaces

RESULTS AND CONCLUSION

This paper evaluated, with a climatic approach, the role of the howzkhaneh's water in the architectural body of the Mosaver-ol-Maleki house in Isfahan. Using a psychrometric analysis of the July design day, conceptual air-circulation schematics, and a validated two-dimensional natural-convection field, it showed that the extreme summer dryness of Isfahan (37 °C, 23% relative humidity) yields a wet-bulb temperature of only 20.1 °C and a theoretical temperature-depression ceiling of 16.9 °C, while the realistic depression achievable by a still pool is about 2–7 °C in the immediate microclimate of the water. The cooling potential is highly sensitive to inlet humidity, collapsing to below 10 °C as relative humidity approaches 50%, which explains both the effectiveness and the cultural elaboration of water architecture on the central plateau. The validated convection field ($|\psi|_{\max} \approx 5.07$) confirmed the closed, stack-driven circulation cell that the schematics assert. The central conclusion is that in the Mosaver-ol-Maleki house water is not an isolated ornamental element but an active component of an integrated climatic system: the octagonal pool supplies evaporation and humidity, the level difference stabilises a reservoir of cool

air, the roof skylight drives stack ventilation, and the sash windows transport the cooled air to the living spaces. The environmental value of the water is realised only when this airflow carries its effect into the body of the house so that it is the design of the howzkhaneh, and not merely the presence of water, that determines the climatic outcome. These findings recommend, for the conservation of historic houses, the revival of the water path and the ventilation mechanism of the howzkhaneh, and, for contemporary design, the reinterpretation of the coupled pool–skylight–opening system as a low-energy cooling device for hot–arid climates. The natural continuation of this work is a full three-dimensional CFD simulation of the surveyed geometry, executing the scenario matrix presented here, to quantify the transfer of the cooling effect from the pool to the living spaces.

REFERENCES

- Ahari, Z., & Habibi, S. M. (2001). *The Isfahan school in urban design*. Tehran: Cultural Research Bureau. [in Persian]
- ASHRAE. (2017). *ASHRAE Handbook-Fundamentals (Ch. 1: Psychrometrics)*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

- Bahadori, M. N. (1978). Passive cooling systems in Iranian architecture. *Scientific American*, 238(2), 144–154. <https://doi.org/10.1038/scientificamerican0278-144>
- Bemanian, M. R., & Amini, M. (2017). Social architecture of the Iranian house. *Journal of Iranian Architecture Studies*. [in Persian]
- Cuce, P. M., & Riffat, S. (2016). A state of the art review of evaporative cooling systems for building applications. *Renewable and Sustainable Energy Reviews*, 54, 1240–1249. <https://doi.org/10.1016/j.rser.2015.10.066>
- De Vahl Davis, G. (1983). Natural convection of air in a square cavity: A bench mark numerical solution. *International Journal for Numerical Methods in Fluids*, 3(3), 249–264. <https://doi.org/10.1002/jld.1650030305>
- Ghobadian, V. (1998). Climatic analysis of the traditional Iranian buildings. Tehran: University of Tehran Press. [in Persian]
- Givoni, B. (1994). *Passive and low energy cooling of buildings*. New York: Van Nostrand Reinhold.
- Haeri Mazandarani, M. R. (2009). *Home, culture, nature: A study of the architecture of historical and contemporary houses*. Tehran: Building and Housing Research Center. [in Persian]
- Haji-Ghasemi, K. (1998). *Ganjnameh: Cyclopaedia of Iranian Islamic architecture - Houses of Isfahan*. Tehran: Shahid Beheshti University. [in Persian]
- Haji-Ghasemi, K. (1999). *Ganjnameh: Cyclopaedia of Iranian Islamic architecture - Houses of Yazd*. Tehran: Shahid Beheshti University. [in Persian]
- Ikemoto, F., Sakura, K., & Astaburuaga, T. A. (2021). The influence of historical irrigation canals on urban morphology in Valencia, Spain. *Land*, 10(7), 745. <https://doi.org/10.3390/land10070745>
- Laureano, P. (2001). *The water atlas: Traditional knowledge to combat desertification* (A. Cirella & A. Whitehouse, Trans.). Paris: UNESCO.
- Mirahmadi, F., & Altan, H. (2018). A solution for future designs using techniques from vernacular architecture in southern Iran. *Sustainable Buildings*, 3, 1. <https://doi.org/10.1051/sbuild/2018002>
- Najaf, S. M. A., & Yaghoubi, M. (2015). Thermal study of a cistern's dome (the case of the Motamed cistern in Lar, Iran). *Energy and Buildings*, 102, 453–466. <https://doi.org/10.1016/j.enbuild.2015.06.015>
- Pirnia, M. K. (2004). *Stylistics of Iranian architecture* (G. H. Memarian, Ed.). Tehran: Soroush Danesh. [in Persian]
- Roaf, S. (2003). *Settlement form and qanat routes in the Yazd province*. In *Qanat, Karez and Kariz*. London: The Middle East Centre, School of Oriental and African Studies.
- Saadatian, O., Haw, L. C., Sopian, K., & Sulaiman, M. Y. (2012). Review of windcatcher technologies. *Renewable and Sustainable Energy Reviews*, 16(3), 1477–1495. <https://doi.org/10.1016/j.rser.2011.11.037>
- Salari, F., & Nouri, M. (2016). An introduction to the culture of water use in Iranian architecture. *Journal of Iranian Architecture & Urbanism*. [in Persian]
- Soflaei, F., Shokouhian, M., & Mofidi Shemirani, S. M. (2016). Traditional Iranian courtyards as microclimate modifiers by considering orientation, dimensions, and proportions. *Frontiers of Architectural Research*, 5(2), 225–238. <https://doi.org/10.1016/j.foar.2016.02.002>
- Soflaei, F., Shokouhian, M., & Soflaei, A. (2017). Traditional courtyard houses as a model for sustainable design: A case study on BWs mesoclimate of Iran. *Frontiers of Architectural Research*, 6(3), 329–345. <https://doi.org/10.1016/j.foar.2017.04.004>
- Soltanzadeh, H. (2017). The importance of water and water elements in the Persian garden. *Manzar*, 9(38). [in Persian]
- Taleghani, M., Tenpierik, M., & van den Dobbelsteen, A. (2014). Energy performance and thermal comfort of courtyard/atrium dwellings in the Netherlands in the light of climate change. *Building and Environment*, 82, 566–579. <https://doi.org/10.1016/j.buildenv.2014.09.028>
- Tavassoli, M. (2003). *Urban structure and architecture in the hot arid zone of Iran*. Tehran: Payam va Peyvand. [in Persian]
- Watson, D., & Labs, K. (1983). *Climatic building design: Energy-efficient building principles and practices*. New York: McGraw-Hill.
- Zamani, Z., Heidari, S., & Hanachi, P. (2018). Reviewing the thermal and microclimatic function of courtyards. *Renewable and Sustainable Energy Reviews*, 93, 580–595. <https://doi.org/10.1016/j.rser.2018.06.015>

[org/10.1016/j.rser.2018.05.055](https://doi.org/10.1016/j.rser.2018.05.055)

- Zamani, Z., Assadi, M., et al. (2019). Energy performance and summer thermal comfort of traditional courtyard buildings in a desert climate. *Environmental Progress & Sustainable Energy*, 38(4), e13256. <https://doi.org/10.1002/ep.13256>
- Reisi, M., & Kasmai, M. (2019). *Climate and architecture*. Tehran: Khak. [in Persian]
- Ostadzadeh, A., Keramati, G., & Ghobadian, V. (2023). The link between water and the spatial organisation of Iranian courtyard houses. *Journal of Architecture and Urban Planning*. [in Persian]
- Kheirabadi, M. (1997). *Iranian cities: Formation and development* (H. Hataminejad & E. Mazhari, Trans.). Tehran. [in Persian]

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