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# Wind Tower Design Based on Climate Adaptability

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**Abstract** Traditional wind towers, as passive cooling building components, represent an outstanding achievement of human wisdom in adapting to extremely hot and arid climates. Taking traditional wind towers in typical regions, including Iran, Iraq, Egypt, Sistan and Hyderabad, as research objects, this paper compares and summarizes the regional adaptation strategies of traditional wind towers in hot-dry climate zones and monsoon climate zones, and further generalizes their locally-adapted, climate-responsive design concepts in terms of morphological combination, material selection and air distribution. On this basis, computational fluid dynamics (CFD) numerical simulations under different design parameters are adopted to systematically analyze the internal air distribution characteristics and ventilation mechanisms of traditional wind towers from two dimensions: site wind direction and tower height. The results show that the surrounding thermal-wind environment and structural morphology jointly determine the overall ventilation performance of wind towers. Orthogonal internal partitions achieve superior ventilation efficiency and stability under multi-directional wind conditions, and reasonable air inlet height and top morphology can significantly improve wind-catching capacity.

**Keywords** Traditional wind towers, Passive ventilation, Fluent simulation, Climate adaptability analysis, Regional analysis
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Traditional wind towers are passive ventilation devices based on climate adaptive design. Their core function is to regulate indoor microclimate and improve indoor thermal comfort through the natural pressure differences caused by heat and wind, as well as the wind-heat synergy effect in the environment. Influenced by geographical environment, climate characteristics and cultural traditions, wind towers in different regions have distinct differences in appearance, construction techniques and functional emphases. Therefore, this paper begins with an analysis on regional climate characteristics to identify the main types and adaptation paths of traditional wind towers through typical cases. Subsequently, it systematically explores the air flow organization mechanisms and ventilation performance differences of wind towers using computational fluid dynamics (CFD) numerical simulation, with a focus on key design parameters such as site wind direction and tower height.

## 1 Regional characteristics of traditional wind towers

### 1.1 Hot and dry climate zone

**1.1.1** Yazd, Iran. Iran has long endured extreme heat, with wind patterns strongly shaped by terrain, resulting in stable and high-speed air currents that offers high-quality wind resources for passive ventilation. Thus, wind towers can be used to regulate the indoor microclimate. During the warm season, the prevailing wind mainly comes from the north to the northeast, while during the cold season, it shifts to the south to the southwest. Wind towers must therefore balance ventilation with sand and dust prevention. The ventilation openings of wind towers are usually equipped with secondary partitioning components, to block sand and dust while accelerating airflow intake. Several types of wind tower photos are shown in Fig.1.

**1.1.1.1** Single-sided wind tower. Common in southern Iranian cities such as Bandar-Abas and Bandar Boushehr, single-sided wind towers are exemplified in Adakan Town, Yazd Province. They feature simple, cost-effective construction with arched facades combining aesthetic and functional purposes. The partition boards extend inward from the ventilation opening and are vertically connected to the inner wall of the tower, dividing the internal space into multiple parallel vertical air ducts. Such design effectively channel the airflow path and prevents larger particles and debris from entering. The top of the wind tower is an inclined guide roof plate at approximately 45° instead of the traditional flat roof, which can more efficiently guide the descending air flow, significantly improving the ventilation efficiency.

**1.1.1.2** Two-sided wind tower. Relatively simple, the two-sided wind tower utilizes a central brick partition to divide the ventilation shaft into two air ducts. This design is suitable for areas with variable wind directions, offering more flexible functions. It can quickly discharge hot air from the intake to the outlet by taking advantage of the wind pressure at the intake. To enhance the cooling effect, the two-sided wind towers integrate wet cloths, water curtains, and a water storage tank or karez water channel at the bottom. The incoming air flow passes over the water surface and generates an evaporation cooling effect, significantly reducing the air temperature while moderately increasing humidity.

**1.1.1.3** Multi-sided wind tower. Situated between two mountain ranges, Yazd experiences stronger and higher air flow speeds than the near-ground level. The wind directions are varied. The local wind towers adopt tall, multi-sided cylinder structures to capture winds from all directions. The multi-sided wind towers in Iran are usually larger and taller than other types, featuring complex and aesthetically pleasing designs[6]. They are divided into four-sided, six-sided, eight-sided and circular ones. Internal partitions include diagonal, orthogonal and composite types, directing airflow precisely to the core living areas such as restaurants and basements through different air ducts. This directional wind guiding technology significantly improves the ventilation efficiency.

**1.1.2** Iraq. In Iraqi, wind towers are mostly mounted on the building parapets, arranged linearly along the wall or staggered in front and back to capture high-altitude airflows. The

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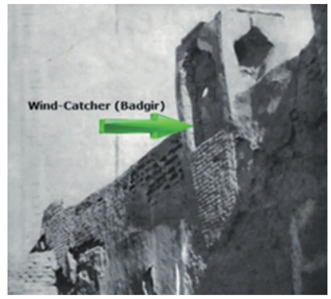
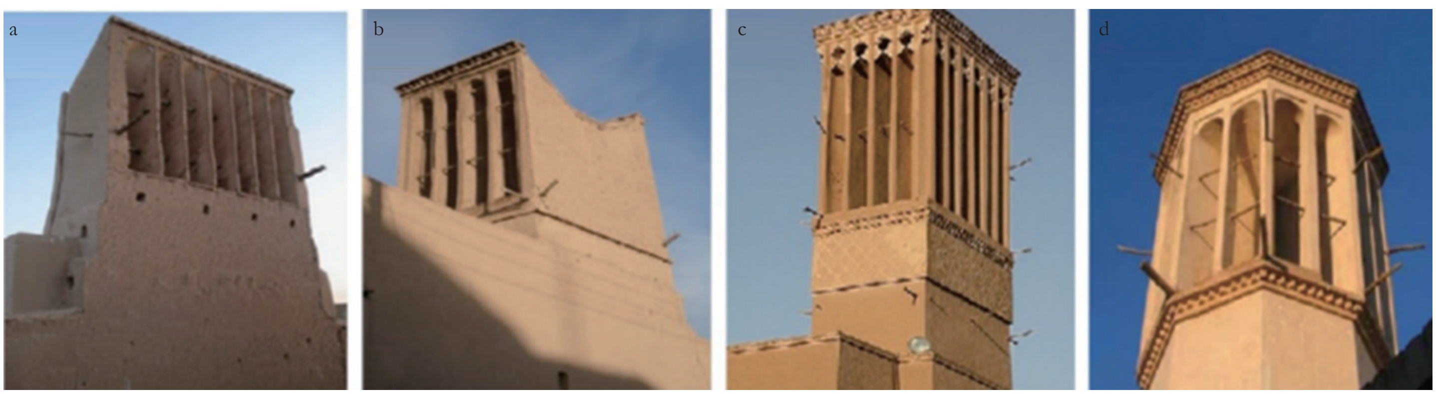
**Table 1 Characteristics of traditional wind towers in hot and dry climate zones[3]**

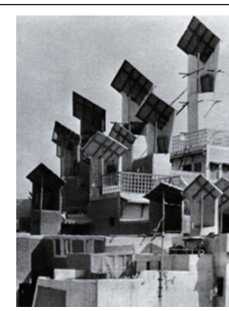
| Item | Iran | Iraq | Egypt |
|---|---|---|---|
| Photo |  Photo source: reference[1] |   Photo source: reference[2] |  Photo source: https://knoji.com/article/types-of-tradi-tional-windca-tcher-malqaf-part-2/ |
| Height//m | 3–5 | 1.8–2.1 | One floor above the roof |
| Cross-sectional shape | Square, rectangle, hexagon, octagon | Rectangle | Rectangle |
| Average size | 0.5 m×0.8 m<br>0.7 m×1.1 m | 0.50 m×0.15 m<br>1.20 m×0.60 m<br>1.80 m×2.10 m | – |
| Top plate structure | 45-degree slope | 45-degree slope | 30-degree slope |



*Note*: a. Single-sided; b. Two-sided; c. Four-sided; d. Eight-sided.

**Fig.1 Classification by opening direction[4]**

**Table 2 Characteristics of traditional wind towers in monsoon climate regions[3]**

| Item | Sistan | Pakistan |
|---|---|---|
| photo |  Photo source: reference[8] |  Photo source: https://publish.illinois.edu/goldwater/ 2015/10 /11/architecture-without-architects/ |
| Height//m | <1 | ⩾ 5 |
| Cross-sectional shape | Rectangle, Square | Square |
| Average size | 0.35 m×0.50 m | 1 m×1 m |
| Top plate structure | 45-degree slope, flat roof | 45-degree slope |

local wind is strong and uniformly distributed. The sloping roof creates a significant negative pressure, thereby enhancing the air intake capacity[2].The tower bodies are mostly constructed with soil bricks with high heat capacity. During passive ventilation, they can absorb some of the air flow heat, precooling the incoming air. Moreover, the materials are locally sourced, making it economically viable. The ventilation openings not only serve as decorations but also help to prevent rainwater from entering in winter.

**1.1.3** Egypt. In response to the dry and windless desert climate of Egypt, local wind towers focus on passive cooling and increasing air humidity. Single-sided wind towers are mostly built on flat roofs with an overall triangular shape, oriented northward to capture cold air from high altitudes. Their low height is conducive to material conservation and is often combined with a water pool beneath the tower, making them suitable for ordinary residences. Traditional Egyptian wind towers are often integrated with a central hall place comprising a main hall and two side halls. The roof of the main hall is slightly higher, with high windows providing natural light and a a passage for indoor air discharge[7].The wind tower above the north side foyer is responsible for capturing cold air and guiding it downward, thereby creating a pressure difference and convection that drives the indoor air circulation. By increasing the size of wind towers, hanging wet pads inside the tower, and setting up water bodies below the middle foyer, the air flow speed and cooling effeccts are strengthened. The scale of the one-way wind towers in Egypt is usually adjusted according to the outdoor air temperature. These towers are typically rectangular, with a length-to-width ratio of approximately 1:2. Triangular tower bodies with a height of about 1.5 to 2 m are set on the roof to achieve passive ventilation within the multi-layer height range of rooms and halls. The roof of the wind tower is composed of a 30° deflector and a wooden filter net set on the windward side to initially filter and prevent debris[3].

### 1.2 Monsoon climate zone

**1.2.1** Sistan. Wind is the dominant climatic factor in Sistan[9].The wind towers here feature flat or dome-shaped roofs for drainage, and low-profile single-direction arched openings for wind resistance. Openings are small to prevent rain entry, with additional low wall openings on the near-ground side of the building and at the high points of the wall to guide the airflow out. Constructed from high-heat-capacity materials like clay bricks or rammed earth, they can reduce heat transfer. Typically less than 1 m high with a 0.35 m × 0.5 m rectangular cross-section, they usually adopts either 45° sloped or flat roofs[3].

**1.2.2** Hyderabad. Influenced by the monsoon climate, Hyderabad features uniform and stable wind distribution, making for superior wind resources. The maximum gust of wind is much stronger than the regular wind. Local towers are predominantly square with a length-to-width ratio of 1:1. Side walls or side panels that are higher than the roof are set on both sides, and the roof is an inclined top plate at approximately 45° and fixed on the side walls. The wind towers adopt a directional wind-catching form. The openings face the southwest monsoon direction. The spoon-shaped internal baffles can concentrate airflow, reduce resistance, and boost intake volume. To capture high-altitude airflows, the towers are usually over 5 m tall. The internal vertical connection leads to the core space of the building, directly introducing the strong monsoon into the living area, promoting the rapid expulsion of hot and humid air from the windows on the leeward side, and improving the discomfort caused by high temperatures and high humidity to the human body. In traditional practices, towers are generally 3–5 m above ground. The roof is often composed of wood combined with plaster or galvanized metal plates. The side walls mostly use wood frame masonry, brick and stone or earthwork materials. At the same time, in the absence of mechanical cooling devices, they serve as the main natural ventilation openings for rooms and living spaces[3].

## 2 Analysis of differences in traditional wind towers based on FLUENT simulation

The traditional analysis of wind tower differences based on FLUENT simulation aims to systematically dissect the intervention mechanisms of different geographical environments and wind tower design elements on the ventilation efficiency of wind towers. The analysis focuses on from two dimensions: site wind direction and wind tower height.

### 2.1 Influence of site wind direction on wind tower design

This study aims to investigate the ventilation mechanisms of four internal partition types under different dominant wind directions. It conducts a comparative analysis of the airflow organization characteristics in two typical working conditions: oblique air intake and direct air intake.

**2.1.1** Simulation object. The simulation objects selected for this study include four typical internal partition layouts: diagonal type, orthogonal type I, orthogonal type II, and composite type (Fig.2). The plan views for direct and oblique intake are shown in Fig.3–4.

The results of CFD simulation show that that there is no significane difference in the ventilation mechanisms of the A-A and B-B sections under the two ventilation modes, so they are not taken as the main research objects. This simulation focuses on analyzing the C-C, D-D, and E-E three sections. Among these three sections, the C-C section corresponds to the intake duct, the D-D section corresponds to the exhaust duct, and the E-E section corresponds to the side ducts. Moreover, the E-E section only appears in the orthogonal II type wind tower plan.

**2.1.2** Simulation variables. This simulation focuses on the differences in ventilation performances of wind towers when wind direction changes, revealing the climatic adaptability of the four typical wind tower layouts. When the dominant incoming wind is set to the northwest direction, it is a diagonal intake condition, and the two openings on all four sides face the wind. When the dominant incoming wind is set to the north, it is a forward intake condition, and only one opening on all four sides faces the wind. CFD simulations were conducted for the four-sided wind towers with diagonal, orthogonal I, orthogonal II, and composite partition methods to study the ventilation mechanism of the four-sided wind towers under different wind direction conditions.

Using the Components speed definition method, the x-component speed was set to 2.4 m/s. The z-axis speed component was 3.2 m/s, and the total northwest incoming wind speed was 4 m/s. Under this condition, the north and west openings are on the windward side, and the wind pressure is positive; the other openings are on the leeward side, and the wind pressure is negative. Driven by wind pressure differences, the airflow enters from the windward side openings, passes through the corresponding channel, and then is delivered downward to the interior. Finally, the air is discharged from the leeward side openings, forming a complete natural ventilation path. The wind speeds inside the wind towers with four different internal partition methods were calculated separately, and the values were uniformly plotted based on the simulation results, with the wind speed ranging from 0 m/s (minimum) to 8.2 m/s (maximum).

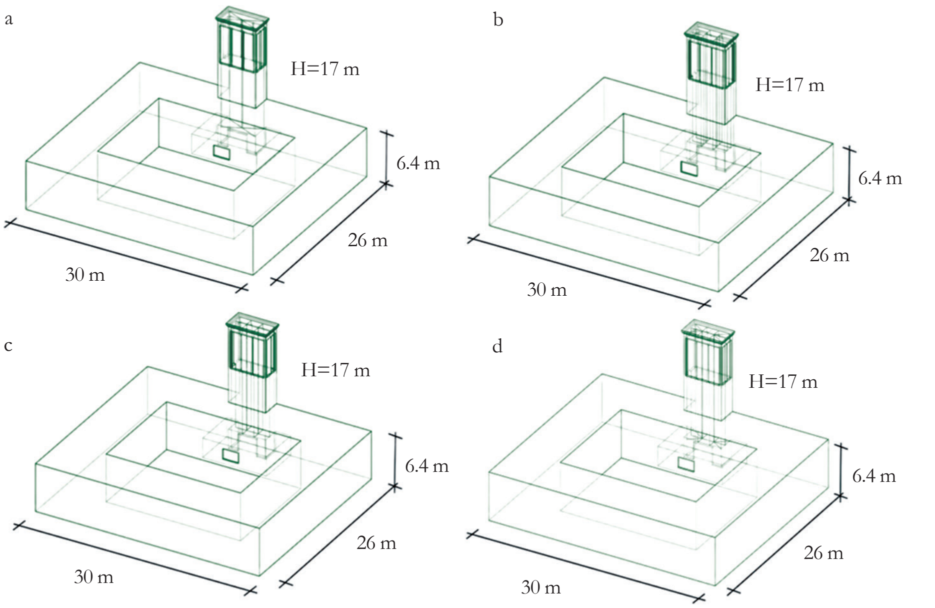
**2.1.3** Simulation result. The wind speed vector diagram of the cross-jointed internal structure is shown in Fig.5. As shown in Fig.3, the partition plates of the cross-jointed internal structure are connected to the four corners of the wind tower, and the airflow is blocked by the partitions and directed to a specific path. In the case of forward air intake, only one of the four wind towers faces the incoming wind, resulting in a single air intake duct. As for oblique air intake, although there are two sides facing the wind, the deflecting effects of the partition plates prevents adjacent openings from being effectively utilized; consequently, only one air intake duct actually performs the air intake function. The ventilation mechanism is basically the same as the forward air intake mode. A brief dual-side air intake state can only be achieved when the incoming air direction is approximately parallel to the oblique partitions.

Therefore, under most oblique prevailing wind conditions, the wind tower with cross-jointed internal structure actually operates in the same way as the forward air intake mode. The cross-jointed wind tower fails to fully utilize the potential advantages of multiple sides facing the wind. Its performance improvement mainly lies in a slight increase in wind speeds, rather than a fundamental change in the flow pattern. The oblique air intake wind speed is slightly higher than the forward air intake.

The wind speed vector diagram of the internal partition of the orthogonal I type air intake tower is shown in Fig.6. When the air approaches from the front, a clear airflow partition is formed inside the air intake tower. On the downward side, all three air ducts exhibit downward airflow, with the central air duct serving as the main downward passage, where the wind speed is significantly higher than that in the air ducts on both sides. On the other hand, the upward airflow speed of the air ducts on both sides of the outlet direction is significantly higher than that of the central air duct. When the air arrives at an oblique angle, the downward airflow speed in the windward side ducts on both sides increases significantly, and together with the central air duct, they become the main downward airflow ducts, and the wind speed is significantly higher than that of the air duct on the side facing the wind alone. This indicates that when the wind direction changes, the ventilation efficiency of the air ducts on both sides of the orthogonal I type air intake tower varies accordingly, while the central air duct, as the core ventilation area, still maintains high efficiency.

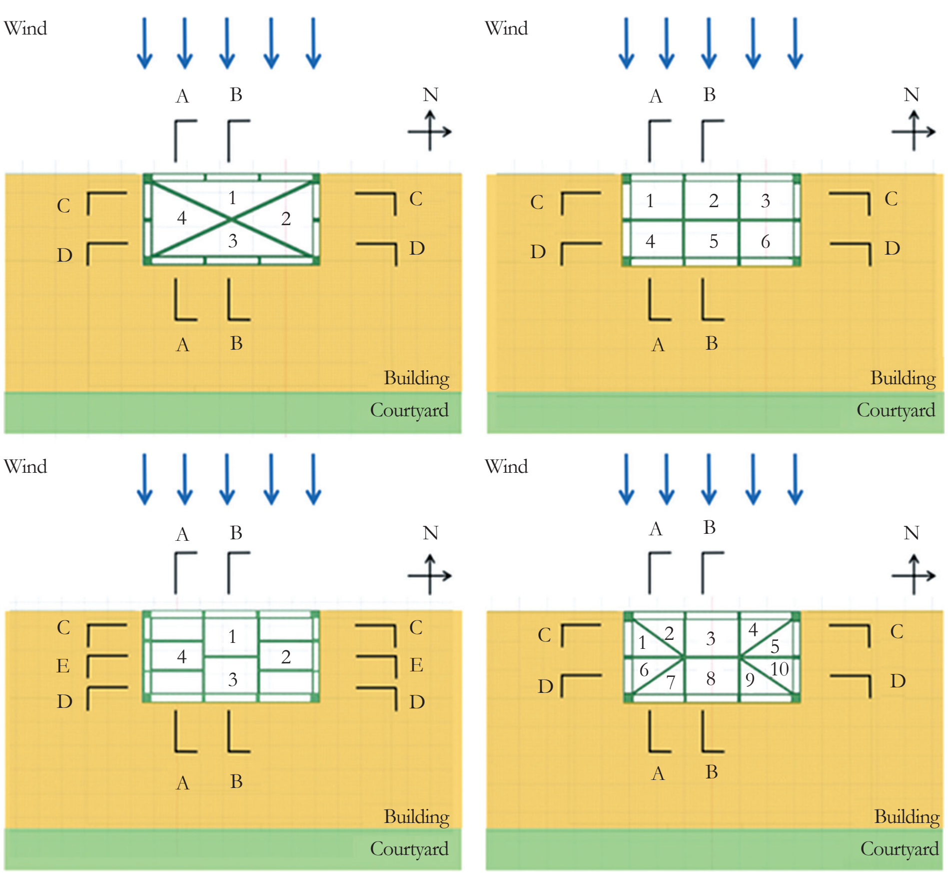
The wind speed vector diagram of the orthogonal II type internal partitioned wind tower is shown in Fig.7. The research data indicates that for both oblique incoming wind and direct incoming wind conditions, the overall airflow organization pattern within this type of structure is completely consistent, differing only in wind speeds. This characteristic suggests that the orthogonal II type ventilation duct layout can effectively eliminate the sudden changes in flow patterns caused by wind direction changes, allowing the airflow to always move along the predetermined efficient path. Notably, among the four structural types, the orthogonal II type wind tower achieves the highest wind speed in all four modes, indicating that this structure performs exceptionally well in terms of wind direction adaptability and also has the strongest ventilation potential. This stable ventilation mechanism gives it significant advantages in variable wind field environments.

The wind speed vector diagram of the composite internal partitioned wind tower is shown in Fig.8. Under frontal incoming wind conditions, the west wind channel does not directly face the northern incoming air and is mainly driven by the thermal pressure effect, presenting an upward flow of air. However, the wind speed is relatively small and does not participate in the operation as the main exhaust




*Note*: Diagonal (upleft), Orthogonal I (upright), Orthogonal II (low left), Composite (low right).

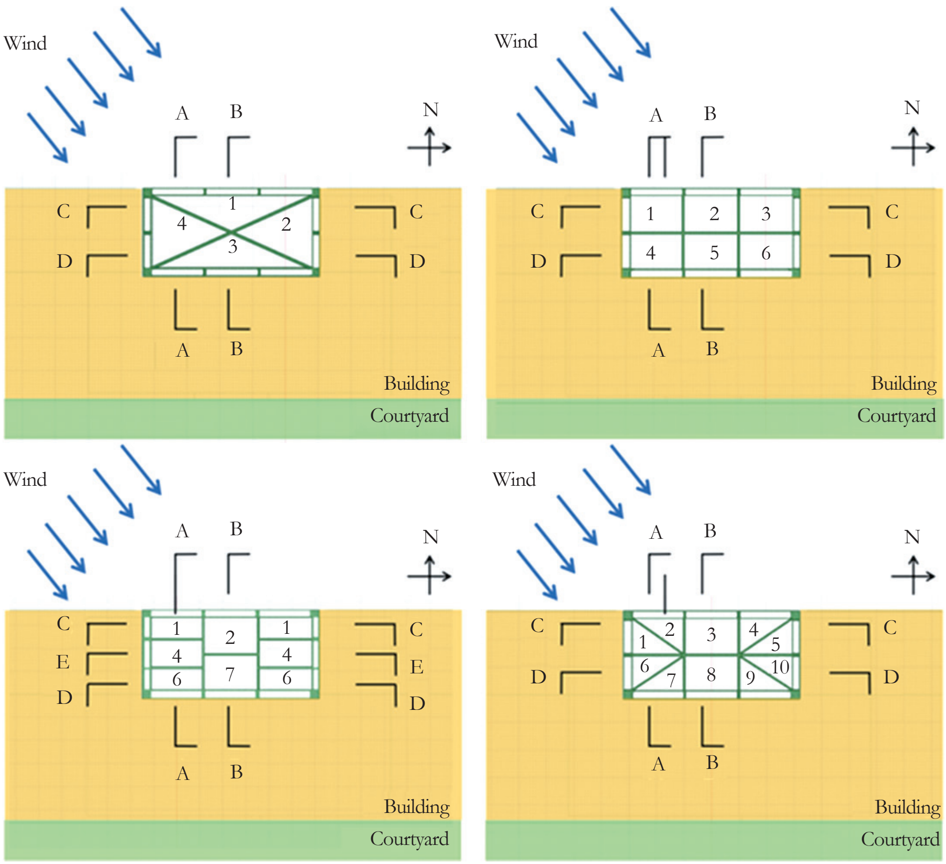
**Fig.2 Four models of wind towers with different internal structures (drawn by the author)**




*Note*: Diagonal (upleft), Orthogonal I (upright), Orthogonal II (low left), Composite (low right).

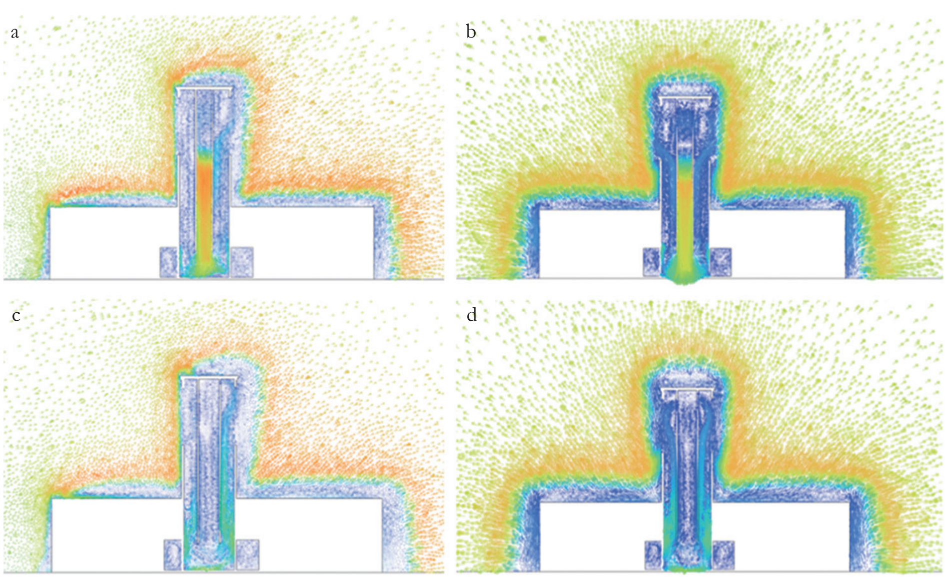
**Fig.3 Plan view of the wind tower under forward air intake condi–tion (drawn by the author)**

channel. When the air enters at an oblique angle, the west wind channel changes to face the incoming air. In this case, the wind pressure and thermal pressure produce a synergistic effect, but the air still maintains the upward flow characteristic, and the wind speed is still small, failing to transform into an effective air intake channel. Apart from this local functional change of the west wind channel, the composite wind tower maintains the same ventilation mechanism in the other wind channels, only with differences in wind speed, proving that its overall ventilation mode has good stability under variable wind directions. This structure, through complex internal partitioning, to a certain extent, balances the ventilation requirements when different directions of incoming air are present.




*Note*: Diagonal (upleft), Orthogonal I (upright), Orthogonal II (low left), Composite (low right).

**Fig.4 Plan view of the wind tower under oblique air intake condition**




*Note*: Diagonal air intake condition C-C section (a), forward air intake condition C-C section (b), Diagonal air intake condition D-D section (c), forward air intake condition D-D section (d).

**Fig.5 Wind speed vector diagram of diagonal structure**

**2.1.4** Simulation conclusion. Under the two typical working conditions of oblique air intake and direct air intake, the overall ventilation mechanism of the four-sided wind towers with different internal partition methods has certain similarities: The wind direction changes when the number of windward openings or the utilization degree of the effective air ducts changes. The wind speed distribution in each air duct and the dominant flow path will be adjusted according to the change of the site wind direction. The internal flow organization pattern of the wind tower remains relatively stable in most configurations. The adaptability of the internal partition method to the wind direction of the wind tower plays a decisive role. Whether different configurations can fully utilize the airflow under the two-sided and multi-sided windward conditions is the key to evaluating the ventilation performance of the wind tower.

Therefore, in climates where natural wind drives and wind direction is varied, orthogonal II type and composite type internal partition are more suitable as the preferred wind tower design schemes. Both can provide stronger ventilation performance and stability. The structural design of orthogonal I type and oblique type is more economical and suitable for wide-scale promotion and application.

## 2.2 The Impact of Airflow Height on Wind Tower Design

The height of the wind tower is one of the core design parameters. It not only defines the vertical dimension as a physical scale but also serves as a decisive variable that affects the distribution of wind pressure gradient, the efficiency of air flow capture, and the potential of thermal ventilation. This study aims to systematically reveal the mechanism by which the height of the wind tower ventilation shafts affects the airflow organization pattern and cooling performance, and to explore how, under specific environmental boundary conditions, the height can be regulated to achieve the optimal passive cooling effect.

**2.2.1** Simulation objects. To clearly analyze the influence of external air flow height on the ventilation performance of the wind tower, a single-sided wind tower instead of a four-sided wind tower is selected as the research object. The four-sided wind tower is larger in volume and has multiple partitions inside, involving the synergy of wind pressure and thermal pressure. The ventilation mechanism is complex, making it difficult to eliminate the interference of other structural factors when used to analyze the influence of air flow height. In contrast, the single-sided wind tower has a simple structure with no internal partitions and a clear airflow path, which can more purely reflect the differences in ventilation effects caused by changes in air flow height. Therefore, it is more suitable as the research carrier for this simulation.

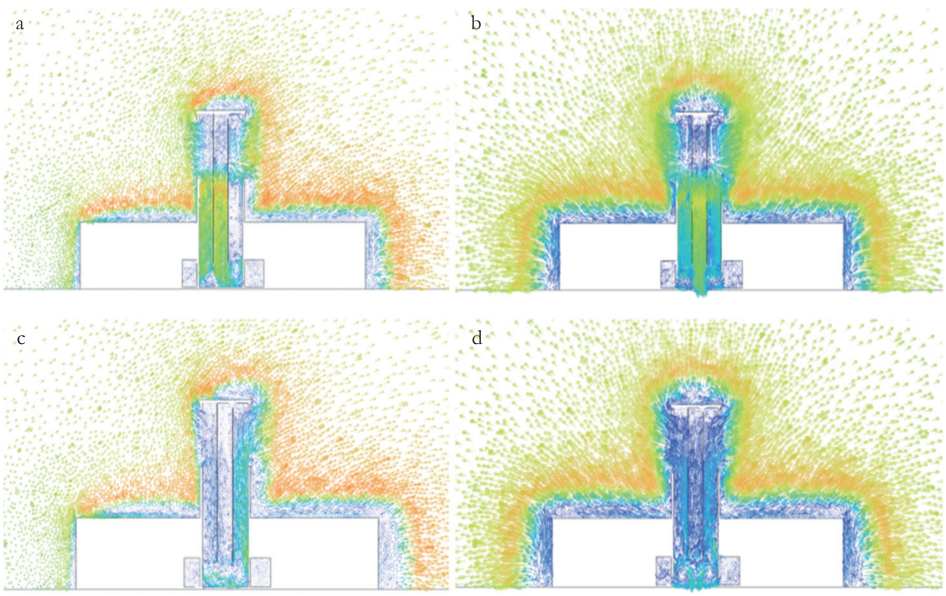
**2.2.2** Structural parameters of the simulation objects. The single-sided wind tower is placed on the roof of a building at an elevation of 3 m, with a common 45° inclined roof structure. The planar size of the ventilation chamber below the wind tower is 6 m×6 m, and the indoor clear height is 3.2 m. To achieve cross ventilation, a window measuring 1.5 m×1.5 m is set on the back wall of the windward side, with a window sill height of 0.9 m. The cross-sectional size of the wind tower is 1 m×1 m, and the size of the intake is 1.5 m×0.8 m.

**2.2.3** Simulation variable. The simulation variable is the height of the wind tower above the roof surface. Three different height schemes are set, including 8 m (representing a traditional tall wind tower much higher than the roof), 5 m (a medium height), and 1 m (a low wind tower close to the roof). Except for the different heights of the out-of-roof height, the other structural parameters are kept consistent.

**2.2.4** Simulation condition settings. To restore the influence of air flow height on the performance of the wind tower in the real environment, this study uses the power-law profile formula for simulation. The roughness index of the dense areas such as trees and low-rise buildings is set at 0.22. The input expression is (y/10[m])^0.22*10[m/s], indicating that the air flow with a speed of 10m/s mainly distributes at a height of 10 m from the ground, and the air flow speed decreases with the increase in height. The calculation results are presented as a wind speed vector diagram (Fig.9). The color scale ranges from blue to red to represent the wind speed from low to high, and the arrows indicate the flow direction.

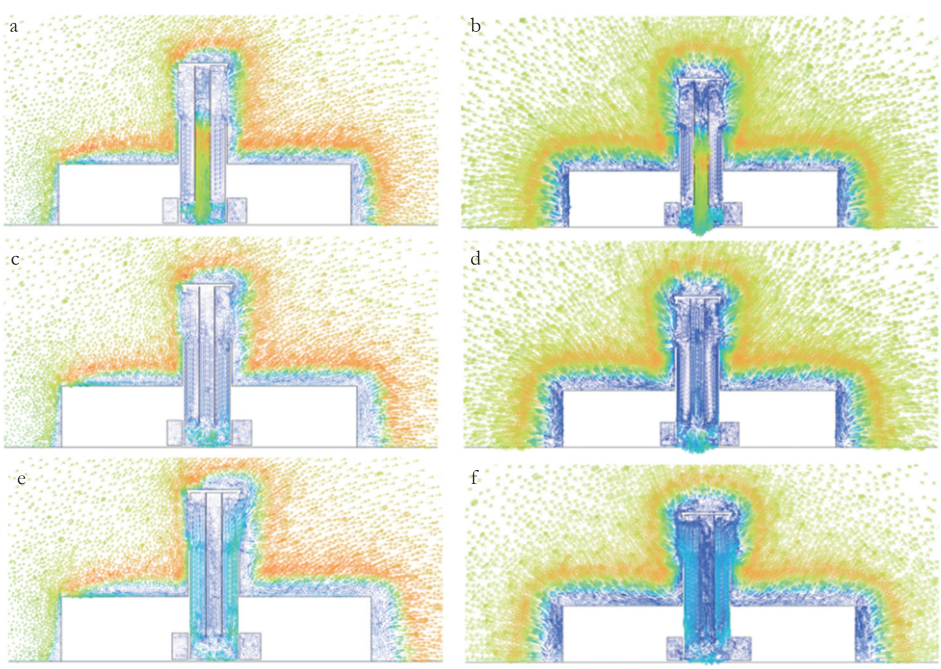
**2.2.5** Simulation Results. As shown in Fig.9, in the three height wind tower environments, the airflow can all enter the tower and flow along the tower wall. The flow path is relatively complete, indicating that all three wind towers can have a wind-catching effect. After entering the wind tower, the air flow all forms a flow acceleration zone, indicating that the wind tower structure can accelerate the airflow. As the height of the wind tower decreases from 8 m to 1 m, the airflow traces and the flow field distribution show significant differences, indicating that the height of the wind tower has a significant impact on the airflow organization.

As the height of the wind tower increases from 1 m to 8 m, the wind tower inlet approaches the high-speed airflow zone, and the downward airflow velocity entering the wind tower increases. The airflow velocity is the highest under the 8 m




*Note*: Diagonal air intake condition C-C section (a), forward air intake condition C-C section (b), Diagonal air intake condition D-D section (c), forward air intake condition D-D section (d).

**Fig.6 Orthogonal type I structure wind speed vector diagram**




*Note*: Diagonal air intake condition C-C section (a), forward air intake condition C-C section (b); Diagonal air intake condition E-E section (c), forward air intake condition E-E section (d); Diagonal air intake condition D-D section (e), forward air intake condition D-D section (f).

**Fig.7 Orthogonal type II structure wind speed vector diagram**

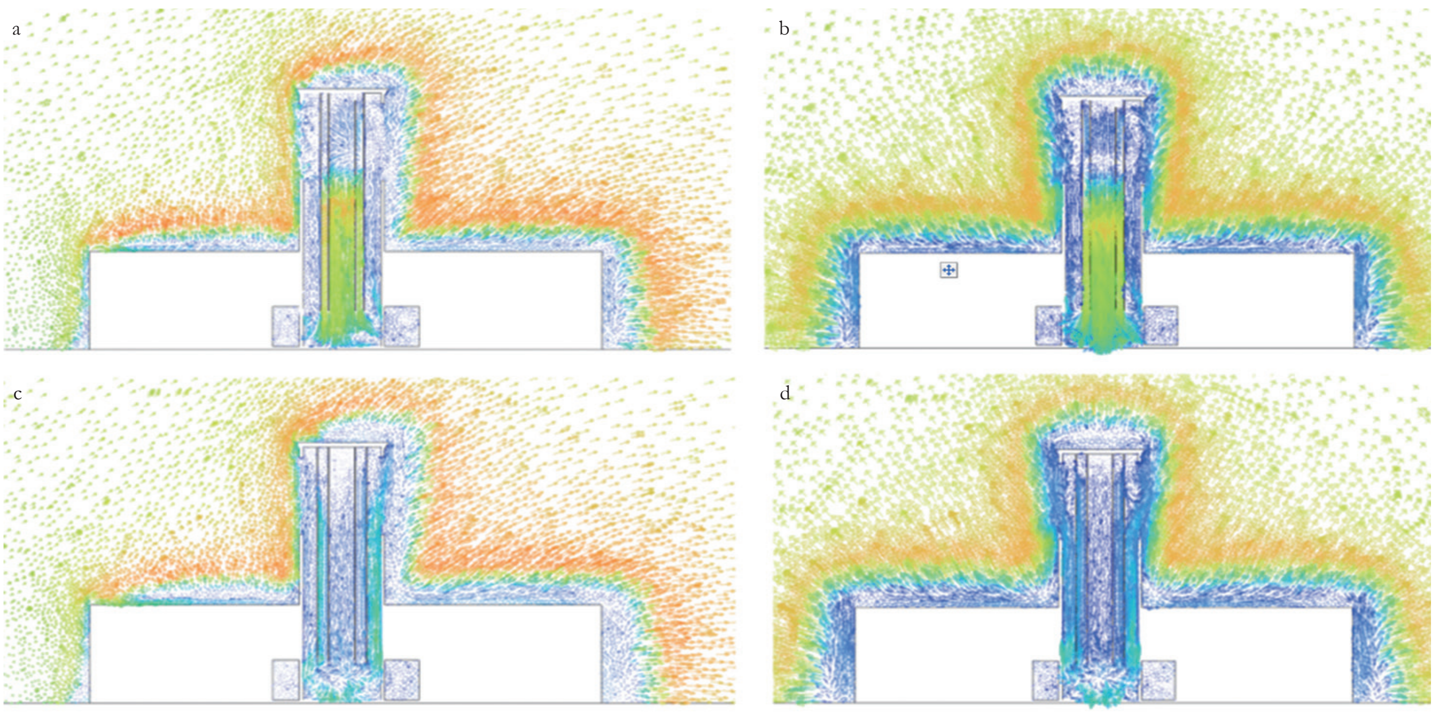
condition, followed by the 5 m condition, and the lowest under the 1 m condition. Thus, the closer the height of the wind tower inlet is to the airflow height, the better the wind-catching effect.

**2.2.6** Simulation Conclusion. The wind tower mainly uses clay as the wall material, which has the characteristics of heat absorption and insulation. Within a certain range, increasing the height of the wind tower can increase the residence time of the airflow in the ventilation shaft, thereby using the heat absorption characteristics of the material to cool the indoor hot air.

Comprehensive analysis shows that the optimal design height of the wind tower is affected by the surrounding flow field. If the height of the inlet is consistent with the airflow height, the ventilation effect is the best. An excessively high wind tower may have an adverse effect on the structural stability, and a balance point needs to be found between performance improvement and cost. On this basis, further optimizing the angle of the top structure of the tower can also better utilize the airflow and improve the wind-catching efficiency.

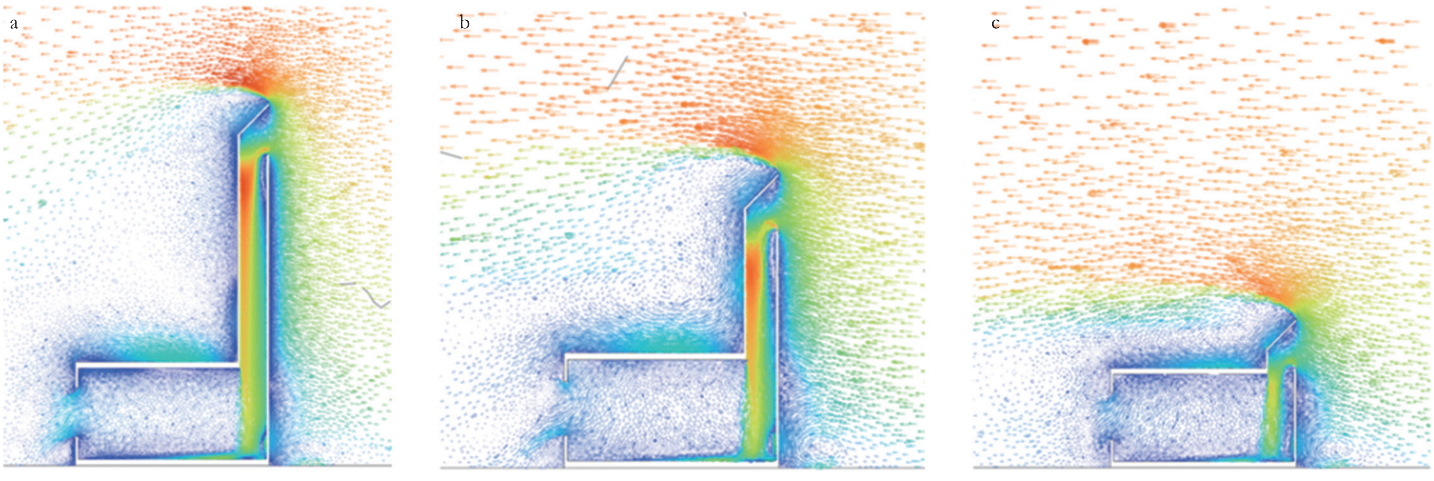
## 3 Conclusion

This study compares the regional adaptation strategies of traditional wind towers in different climate zones through case studies of wind towers in hot-dry and monsoon climate areas. In hot-dry regions, wind towers mainly address extreme high temperatures, strong sunlight, and sandstorms. In Iran, wind towers with single, double, or multi-opening designs are used, combined with wet cloths, water curtains, water tanks, or underground water channels to achieve evaporative cooling. In Iraq, wind




*Note*: Diagonal air intake condition C-C section (a), forward air intake condition C-C section (b); Diagonal air intake condition D-D section (c), forward air intake condition D-D section (d).

**Fig.8 Wind speed vector diagram of composite structure**




*Note*: The height of the wind tower is 8 m (a), 5 m (b), and 1 m (c).

**Fig.9 Velocity vector diagrams of wind towers at different heights**

towers are placed on the parapets, using the negative pressure of the sloping roof and high heat capacity masonry materials to enhance the efficiency of air intake, and absorbing heat with the wind tower materials to cool down. In Egypt, north-facing triangular single-sided wind towers are combined with central hall space, organizing vertical air currents with wet pads, water bodies, and high windows, thereby achieving the dual goals of cooling and humidification under dry and windy conditions.

In monsoon climate areas, wind towers emphasize addressing seasonal changes in wind direction. In Sistan, low single-directional arched small wind towers are used, combined with flat or round roofs, small-scale rectangular sections, and high heat capacity materials such as clay bricks and rammed earth, reducing water infiltration through small openings and horizontal or inclined roofs and weakening heat transfer. In Hyderabad, stable and strong monsoon resources are used to develop spoon-shaped directional wind-catching towers, with a 45-degree inclined roof to concentrate the airflow, channeling the strong wind from higher areas into the core space of the building and quickly expelling hot and humid air through the backwind side windows. Traditional wind towers have formed regionalized forms, materials, and airflow organization patterns tailored to local conditions.

Based on the above regional analysis, CFD numerical simulations with different design parameters were used to quantitatively analyze the factors influencing the design of wind towers under different regional conditions and explore the climate-adaptive design strategies of wind towers. The main conclusions can be summarized as follows:

(1) In terms of site wind direction types, the overall ventilation mechanism of the four-sided wind towers with internal partitions shows a certain consistency in the two typical working conditions of oblique intake and direct intake: changes in wind direction mainly affect the internal flow field by altering the number of windward openings and the participation degree of effective air ducts. The wind speed distribution and dominant flow paths of different air ducts adjust with the site wind directions, while the flow organization pattern within most configurations remains relatively stable. The internal partitioning method has a decisive influence on the wind direction adaptability of wind towers. A key indicator for evaluating the ventilation performance of the wind towers is whether different configurations can fully mobilize multiple air ducts for ventilation in two-sided and multi-sided windward conditions. Comprehensive comparison shows that ortho-gonal II and composite partitioning methods have stronger ventilation capacity and stability in multi-directional wind conditions, making them suitable as priority design schemes for areas driven by natural wind with variable wind directions; orthogonal I and inclined configurations have the advantages of rela-tively simple structure and better economy, and are more suitable for wide-scale building applications.

(2) In terms of wind tower height types, the optimal design height of the wind tower is significantly constrained by the characteristics of the surrounding flow field. When the height of the intake openings matches the height of the dominant airflow in the site, the wind tower can achieve the best ventilation effect; if the height deviates from the effective wind energy concentration area, the wind-catching efficiency will significantly decrease. Although an overly tall wind tower may gain some local wind speed benefits, it will bring an increase in structural stability and construction costs, so a reasonable balance needs to be achieved between ventilation performance improvement and structural safety and economy. Within a reasonable height range, further optimizing the angle and shape of the tower top structure can more fully utilize the upper air flow energy and enhance the wind-catching capacity and the orderliness of the internal airflow organization.

In conclusion, this study uses CFD simulation and comparative analysis of two dimensions—site wind direction and tower height—to systematically reveal the airflow organization characteristics and ventilation mechanisms of wind towers under different design parameter combinations, clearly identifying the preferred design strategies suitable for different climate conditions and functional requirements, providing scientific basis and technical support for subsequent wind tower optimization design and engineering application.

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