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Comparative analysis on architectural characters of Iranian wind catchers in hot arid (case study: Yazd & Bandar Lengeh)

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ABSTRACT

The aim of this study is investigating wind catchers that commonly observe in two Iran's cities, Yazd and Bandar Lengeh with different hot-dry and hot-humid climates. The traditional architecture of Persian residency is the product of Iran's hot climate and arid environment as the most fundamental element for the development of architectural designs. Wind catchers which used to be a part of Iranian houses in warm regions provide cooling comfort by making the energy of wind a renewable resource. In the hot regions of Iran, the predominant architectural styles of vernacular houses exhibit a central courtyard and in the present work we study the wind catchers chosen from such houses in Yazd and Bandar Lengeh. They are constructed in the summer part of house and service to the main living rooms, large reception halls and in some cases, basement. Hypothesis was addressed: 1) Architecture of wind catchers is influenced by the climatic factors that it means wind catchers in different climate have different structure features.
The architectural differences were assessed with a list of 20 items. 18 assessment items proved that the climatic differences deal with these differences. The present study was based on a field survey and analyzed by Excel. The research method was an analytical-descriptive approach.

1. Introduction

Wind catchers are canals with the height of 3 meters mounted vertically on top of house roofs looking like a chimney. The outlet openings in the upper end play an effective role in modifying the heat and adjusting and regulating the temperature of the living space as appropriate for residents' comfort through convective wind flow using pure natural energy of nature. The predominant features of wind catchers set up in Yazd and Bandar Lengeh are their plane shape of square and also their allowances to convention of wind through around all four sides of their ducts.

The canal of a wind catcher is usually divided into smaller ones by means of some blades. These blades rise 1.5-2 meters high above the ground floor of the building and reach to the wind catchers' roof (Roaf, 1988). While the wind blowing, the canal facing windward captures the air at the inlet named "*badkhor*" and the other canals facing leeward evacuate the hot air from the bottom to the upper part of the wind catcher named "*badkhan*" by the phenomenon of air convention.

1.1. Main objectives of the study and main problem

This study investigates effect of climate condition on architectural features of wind catchers in different climate which is help to have best efficacy in each climate.

2. Method of research

Field survey achieved 53 and 39 wind catchers respectively from Yazd and Bandar Lengeh that randomly were selected in different neighborhoods through precision measure (Fig1 and Fig. 2) Field research methods were used in this article. The typology of the wind-catchers is done by the physical analyzing, patterns and common concepts as incorporated in them. From the architecture point of view, comparative analysis between Yazd & Bandar Lengeh was done at the first time. We put all Data of wind catcher in each city in data Sheath then We use Excel to illustrate abundance of them in different value therefore with regards to this we can conclude our data with inductive reasoning.

2.1. Effective factors in optimized function of wind catchers

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Wind catcher has indicated different actions in hot and dry climate. In these regions wind ward can create comfortable situation with enhancement of wind speed and humidity. The evaporation process is the mechanism of performance in Yazd wind catchers because of low air humidity of the environment. The system is worked via water clay pots put nearby the wind catcher duct, or via a water pond constructed next to the wind catcher duct.

Fig 1: Sample of Yazd wind catcher

Fig 2: Sample of Bandar Lengeh

The increased of air velocity can created by dividing the wind catcher channels to the smaller size. According to the Bernoulli's principle, an increase in speed of air occurs simultaneously with a decrease in area and the theory that the increase of 1c of whether temperature in balance humidity (under 70 %) can compensate by 0.15 m/s" (Mc caarthy, 2001), the geometrical shape and height of channels play the important rules.

In a warm and dry climate specially in Bandar Lengeh the main rule of wind catcher is ventilate the air in order to exclude the humidity .as we find humid air weight heavier than dry one therefore the more air enter the wind catcher the better it works. It should be remembered that in this region the win catcher works only by cooling convection.

The architectural issues effect on a wind catcher actions are: direction, location, height and geometrical plans of wind catcher

2.2. Evaluation and classification of effective issues on acting the wind catcher in Yazd

Statics result of the study of 53 Yazd wind catcher demonstrated that 94.3%of wind catcher have 4 sides, Beyond this 4side wind catcher is given by 94% of the total have rectangular shape in plan (Mahmoudi Zarandi, 2009a). Rectangular wind catcher provides a higher efficiency by comparing to another section (Montazeri, 2011).

Internally divided by adobe-brick made blades, wind catchers represent different cross-sectional forms of their inner smaller ducts created by a variation of blade positions as +, H form (Table1).

Other shapes of bleds such as X, K and I are the rarest. The canal divisions are aligned such that each duct captures wind only via a unidirectional inlet opening; otherwise wind enters through an opening and flows out via the other opening of the wind catcher. Generally the induced air flow rate decrease by increasing the number of opening.

In this article we try to categories the wind catchers according to the dominate form.

Based on what we described in this article, the typology of wind catcher plans (Mahmoudi Zarandi, 2009b) and the result of study of 47 wind catchers, we categorized wind catchers in two groups as common concepts (Table 1).

The architectural differences between these groups are:

Group A:

- A wind catcher positioned behind the hall its axis of symmetry. In this type of wind catcher, - - the axis of symmetry, hall and courtyard extend together.
- Service providing spaces are basement and the hall.
- The main direction on these is in northwest
- The dominate form of internal blades are + shape.

Group B:

- A wind catcher positioned on a corner of a yard: this type requires that wind catcher connected to the hall through the medium of a pond room entitled *hozkhane* but not directly related to it.
- Placing the pond in middle of *Hozkhane* cause the more cooling process.
- The direction of these louvers are perpendicular to the A type and faced to the north east.
- The dominate form of internal blades are H shape.

Fig. 3 show the numerous number of wind catchers type in Yazd.

2.3. Bandar Lengeh Wind catchers

Wind catchers are remarkable architectural elements in urban landscape of Bandar Lengeh facing to the sea to capture air flow circulated between land and sea. Bandar Lengeh wind catchers are towers with square or oblong plan divided

internally into 4 smaller ducts by means of X-form blades (Table 2).

Table 1: Typology of Yazd wind catchers as common samples

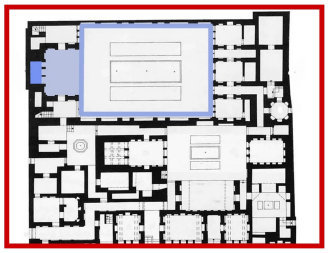
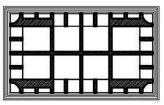
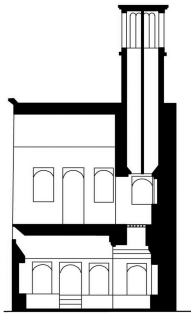
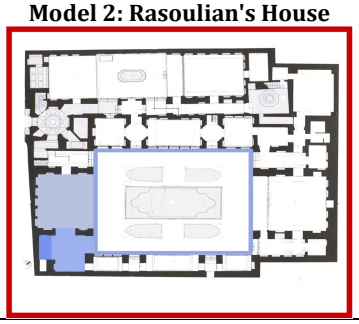
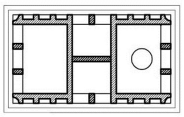
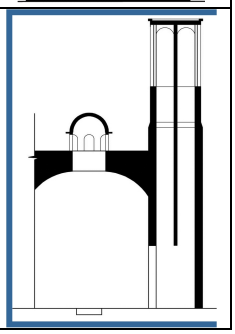
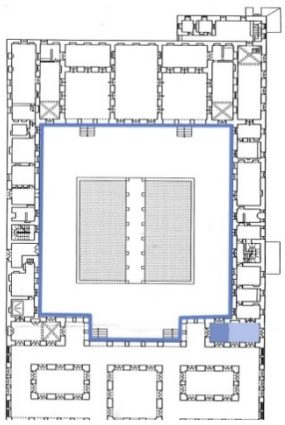
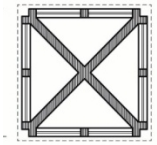
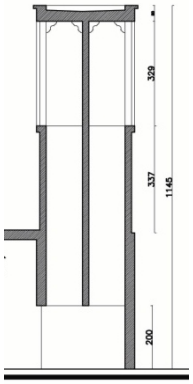
City:Yazd	House plan	Wind catcher plan	Wind catcher cross-sections
Type A	Model 1: Mahmoudi's House 		
Type B	Model 2: Rasoulian's House 		

Table 2: General type of wind catcher in Bandar Lengeh

City	House plan	Wind catcher plan	Wind catcher cross-sections
Bandar Lengeh	 Fekri's House		

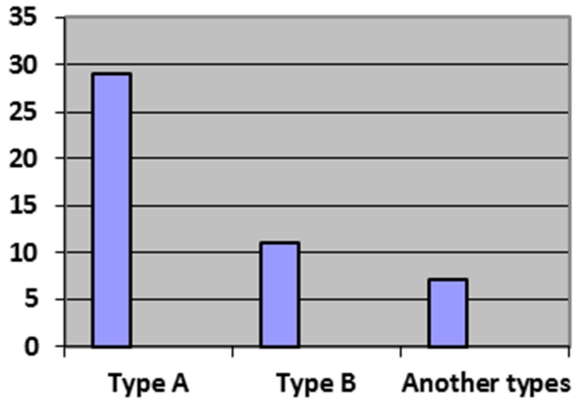


Fig 3: majority of 2 groups in Yazd

The air flow enters from the upper openings and canalizes into the bottom of wind catcher. The height of Bandar Lengeh wind catchers is nearly 3 meter with a standard deviation of 50 cm considered in some cases (Mahmoudi Zarandi, 2009b). The height range is 5.85-12.43 meters. The conventional height is 7.5-8 meters and a height more than 9 meters is seen in the wind catchers installed on the two-floor houses' roofs mainly for service to the second floor.

From 39 surveyed wind catchers, 27 and 12 have square and oblong plans, respectively. The oblong plans have the symmetry very similar to that of the square plans. Bandar Lengeh wind catchers are shorter and wider according to their symmetry. They are constructed wider in order to increase the inlet air Debye to remove away the muggy air and humidity of the living spaces. They are constructed short because of sea-land breezing at low altitudes.

As humid air is heavy, the inlet cooling air makes it to be removed out from all sides of rooms. This function repeats over and over to achieve a more pleasant and cooler environment at the space located under wind catcher compared to that of outdoor or other spaces. Because of high humidity, their function is based on the conventional cooling system without a need to provide humidity nearby them similar to that seen in Yazd wind catchers.

3. Comparative analysis of wind catchers

The summaries of results obtained from the field studies are presented in Table 3 through a comparative analysis.

By considering important of wind catchers high from roof and area of plan we comparison this feature in Yazd and Bandar Lengeh with each other in Fig. 4 and Fig. 5.

4. Result

The traditional architecture of Iran is the product of land, the local climate, and people's architectural culture. The human needs and environmental condition are combined as the most essential factors in designs of architectural elements. Some elements such as wind catchers are as effective solutions and devices for climatic difficulties.

There is abundant study about wind catchers as Natural Ventilation, wind catchers structure and architectural symbol.

past studies investigate wind catchers elaboration in function of them this paper shows that most architectural differences between wind catchers of Yazd & Bandar Lengeh that it caused by different climate features which is not consider in other studies.

For first time this study examined affects of climate as most important factor in wind catchers architectural structure.

18 items of 20 items proved that climatic factors caused wind catchers different characteristic.

According to this survey and common types the most important points about Yazd wind catchers are as follows:

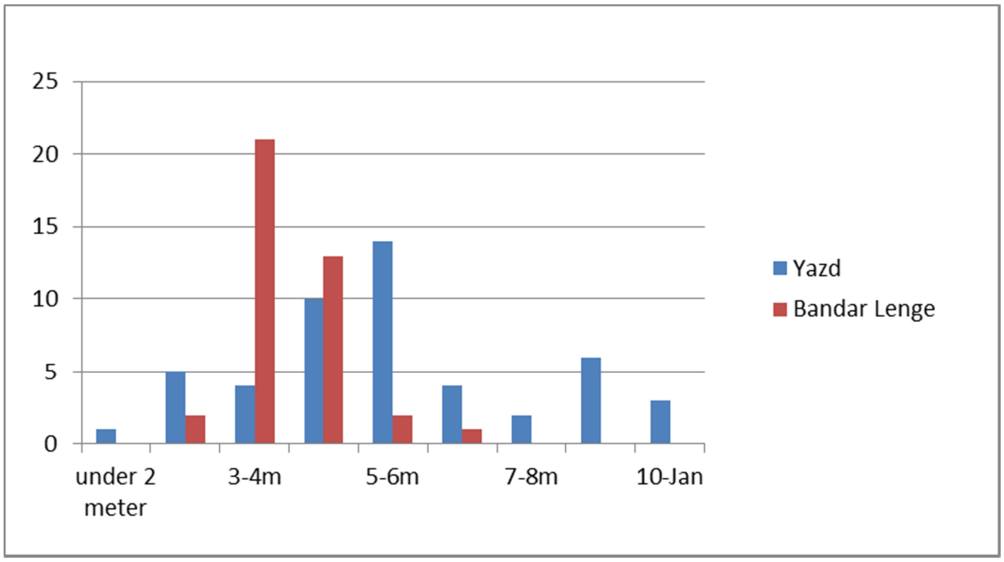


Fig 4: Compering of wind catcher high in Yazd and Bandar Lengeh

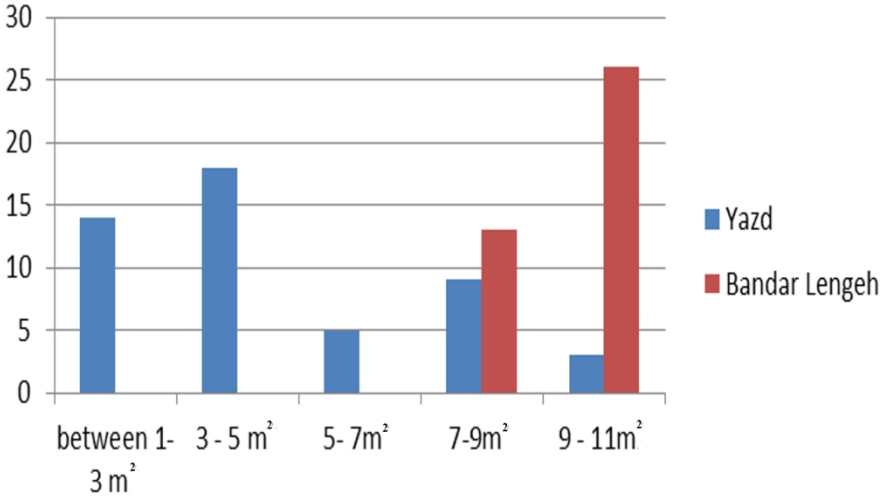


Fig 5: Abundance of wind catcher with specifics area of plan

Table 3: Comparative architectural analysis of wind catchers in Yazd and Bandar Lengeh

Variables		Yazd	Bandar Lengeh	Completion
Wind catcher direction		North, Western North, Eastern North (Dominant direction in Yazd (62.26%) is Western North)	15-45° tended to Western North	Dominant wind direction is the reason of choosing wind catcher direction
Set up place in house plan		Southern side of building (It's usually directed to geographical eastern south)	Variably in every sides but usually in southern and western sides	Set up at sides of summer house
Type based on number of sides captured wind		Four-side, Two- or 8-side in some cases	Four-side	Hourly and daily change of favorable blown wind in all four sides
Average number per house		1	2	The necessity of more inlet air volume for ventilation
Serviced spaces		Hall, pond room, basement	Wind catcher room	For high humidity and risen surface waters in Bandar Lengeh, there is no pond room and basement.
Wind catcher roof shape		Flat	Flat	For low raining in both cities
Color and exterior texture		Rough and clay-straw plastered	White and polished	Rough in Yazd for preventing to absorb light; polished in Bandar Lengeh for reflecting light.
Plan	Area	4.8-17 m^2 Average: 3-6 m^2	4.65-12.25 m^2 (Conventional average: 9 m^2)	Areas of most wind catchers in Bandar Lengeh cause more inlet air volume to enter
	Geometrical form	Square, oblong, octagonal	Square, oblong	Variety observed in plan of Yazd wind catchers, again
	Predominant form	Oblong	Square	Reasons for square plans in Bandar Lengeh: 1) set up in house plan 2) equal value of four wind directions 3) convenient performance
	Oblong symmetry	1.25-2.5 m (1.4 is conventional)	1.02-1.25 m (exception: one as 1.93 m)	Bandar Lengeh wind catchers have square plans and oblong symmetries near to square
	Square symmetry	< 2 m (1.6-1.85 m)	2 m (±30-40 cm)	Wider in Bandar Lengeh
	Blade form	I, K, X, H	X	Architects tended to X-form because of weak techniques in Bandar Lengeh
	Height range	6.5-19.74 m (exception: 33.5 m in Dolat-Abad wind catchers)	5.85-12.42 m	Wind blowing with lower dust at higher latitude in Yazd
Height	Average height	8.5 m	7.5 m	Sea-land breezing at low latitude as near to sea surface in Bandar Lengeh
	Height range (from house roof)	2.5-10.86 m	2.75-8 m	higher wind catcher, higher wind catcher shaft and higher height measured from roof
	Predominant height	5 m	3.5 m	No such landscape in Bandar Lengeh as Yazd exhibits because of their short-height wind catchers
	Height range of blade (from house floor)	2-2.6 m	1.6-2.5 m	Measured from floor because of space under wind catcher
	Predominant height of blades (from house floor)	2.5 m	1.8 m	No architectural/functional reason

1. The wind catcher of Yazd should be connected to a humid surface considered somewhere between the wind catcher and the main room. The air current should not be arranged to flow directly from the wind catcher to the main room. It should be turned at an angle of 90 degree or 180 degree to cause to current vortex and consequently to increase the evaporation process. But about Bandar Lengeh the wind catcher is directly

connected to the main room without any water surface in the room.

2. The best performance of Yazd belongs to the oblong plans with the symmetry of 1-1.5 and performance of Bandar Lengeh wind catcher belongs to the square plans with the dimensions of about 3 meters and X-form blades.
3. Wind catcher height will improve wind catchers operation. Evaporation efficiency is proportional to air volume in constant speed (Bahadori, 1985). Predominant height of wind catchers from house roof is 5 m for Yazd city and 3.5 m for wind catchers of Bandar Lengeh.
4. areas of most wind catchers in Yazd is between 3-5 m^2 in average and conventional average area of wind catchers in Bandar Lengeh is 9 m^2.

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