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ON WIND CATCHER INTEGRATION IN CONTEMPORARY BUILDINGS IN JEDDAH

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Abstract

Jeddah City is a hot, arid zone and is characterized by high air temperatures and humidity. New architecture shall be undertaken by attempting to achieve the paradigm of natural ventilation and initiatives should be aimed at minimizing the harmful effects of a harsh environment on city inhabitants (Mohamed and Fekry, 2018). This paper focuses on finding reasons behind the negligence of wind catcher use, in contemporary residential buildings, in the city of Jeddah– it employs both semi-structured interviews and questionnaires with residents and professionals, to illustrate their opinions. Results show a relative lack of awareness among residents regarding passive strategies overall and wind catchers, in particular. Results also show, however, tangible potential among professionals to adapt passive strategies and tools. Most importantly, this paper attempts to illustrate how the survey's results are contrary to conventional belief: that high levels of humidity, temperature, dust and safety issues are primary reasons for the negligence of natural ventilation strategies in Jeddah.

Keywords: *Wind catcher, passive strategies and measures, heritage interventions, subjective assessment*

Introduction and Research background

Jeddah City is characterized as being a coastal, longitudinal city with a hot and arid climate. Its urban fabric is distinguished by the organization of structures and the grid-like layout of its streets; optimum orientation should increase airflow and cross ventilation. Previous researchers have demonstrated significant findings, related to minimizing annual energy consumption of a residential building in hot, humid and arid zones (Hanan, 2014; Nayer, 2013a,b; Mohamed, 2018); consumption may be reduced when a building employs passive cooling strategies. Traditional building techniques, such as earth construction, have withstood the test of time; their effectiveness and intelligence, in responding to the socio-cultural and climatic context of many regions, has been well demonstrated (Mohamed, 2010). Recent architecture approaches are aiming to adapt traditional techniques from the past (Patel and Rajan, 2015; El-Borombaly, 2015; Okasha. et al., 2016). Many Saudi Arabian regions are borne out of their heritage districts and are characterized

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by vernacular and traditional buildings; this reflects social, cultural and environmental expressions of the interaction between natural and cultural forces (Fatani et al., 2017). These districts and its old buildings were, until recently, the traditional nucleus of many cities and towns. Nevertheless, accelerating urban growth and lack of interest from locals, in these old buildings, has led to the negligence and subsequently the demolition and removal of many structures with significant cultural value. As long as such practices persist, cities and towns risk the loss of their identity and cultural diversity (Mohamed et al., 2018).

It is worth mentioning that any traditional technique is not performed as well as we may think, at all times. It is more important to use local techniques, in combination with the appropriate passive design strategies and measures (Mohamed, 2009, 2010; Mohamed and Gado, 2009). Previous researchers (Kamal, 2014; Al-Ban, 2016; Fatani et al. 2017;) have investigated the adaptation of passive, architectural solutions in Jeddah's Context. They presented effective integrations of 'rawasheens', courtyards and shaded open spaces within Old Balad, as well as within contemporary sites in Jeddah (such as the King Abdallah University for Science and Technology, or KAUST).

Another famous example in Jeddah is the Al Diwanyia Rest House, in Al Saffa District, characterized by its contemporary vernacular architecture. A wind tower is a major element in passive strategies; one was adopted in the building's context, also, in the internal courtyard (Figure 1a). The passive system adopted is considered to be most efficient, according to Dipak (Patel and Rajan, 2015). A multi-directional wind catcher, presented schematically in Figure 3b, simulates airflow control in various directions and is considered to be an environment-friendly solution for more comfortable and energy-efficient buildings.

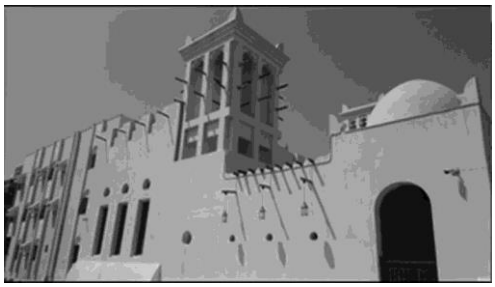

Figure 1a. *Wind Catcher within El Diwania Rest House, El Rawda district, Jeddah, Research Team*

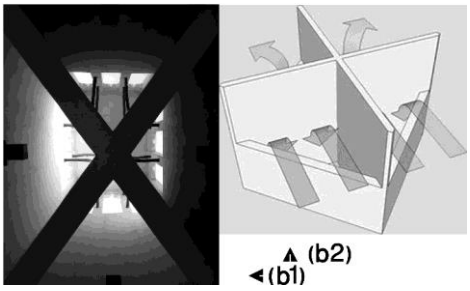

Figure 1b. *Schematic Airflow directions; a picture captured by the authors.*

Another example is the Al-Makkiyah Residential Villa (Residence of Sami Anguawi); it presents an approach of distinguishing vernacular, Hijazi-style architecture. According to Agha Khan (Khan, 2007), natural ventilation techniques like the one used in the famous residence of Sami Anguawi (erected in 1980), minimize the need for air-conditioning– even during summer months. According to functional space arrangements, as shown in Figures 4a and 4b: natural ventilation

and lighting provides connectivity between vertical towers openings; shaded courts and 'rawasheens' provide relevant openings, and consequently, indoor comfort for building occupants.

Figure 2a
Cross section demonstrating the integration of wind towers with the courtyard, (Khan, 2007)

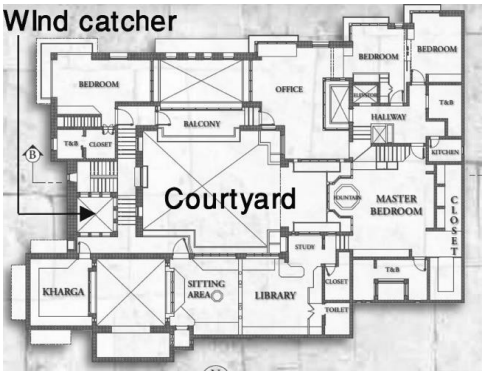

Figure 2b
Plan in the building indicating the position of the wind catcher with the courtyard (Khan, 2007)

A study for Al Sulaimania Palace, in El Hamra District, by Abdel-Wahed El-Wakil (architect/planner) and AghaKhan Trust for Culture (Alsammarae, 2017) reflects the integration of passive strategies and relevant solutions, to provide natural indoor ventilation through the combination of: vaulted spaces, domes and wind-catchers. These strategies and solutions are illustrated within a typical vernacular, architectural context in Figure 3.

Many researchers (Fatani et al., 2017; Gado et al., 2010; Mohamed, 2010, 2014, 2017) have proven that a lack of awareness in the importance of conserving historic sites and landmarks, along with the dependence on government initiatives, have contributed to the progressive decay and destruction of traditional settlements. A similar study (Gado et al., 2010) confirmed that a lack of experience, in contemporaneous oasis inhabitants and a blatant lack of support from the Egyptian Supreme Council of Antiquities, had led to the deterioration of traditional architecture. Their findings confirmed a need to initiate debate, within the community, regarding the social potential of earthy construction and what is considered to be 'modern'.

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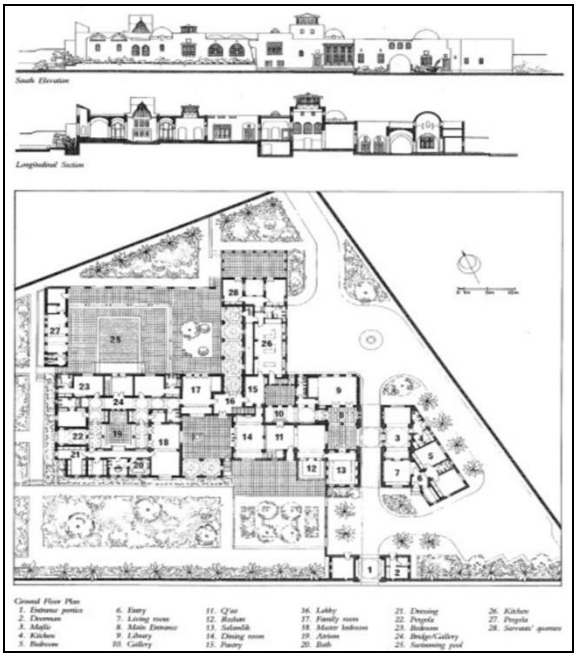

Figure 3

The integration of vaulted spaces, domes and wind-catchers in Al-Sulaimania Palace (Khan, 2007)

Research aims and objectives

This paper aims to investigate the potential revival of wind catcher use in Jeddah; this will be fulfilled through the following objectives:

a) survey contemporary Jeddah architecture that has applied the usage of a wind catcher;

b) conduct a subjective assessment of occupants, professionals and stakeholders to identify the main reasons behind negligence of the wind catcher, as well as future existence potential.

Through completion of objectives will aid in identifying the reasons and/or problems that lead to the negligence of such a passive tool, in order to find the appropriate solutions.

Research methodology

This portion of research depended on survey research. A group of graduate and undergraduate students conducted a survey, under supervision of the authors. The survey employed semi-structured interviews, self-directed questionnaires and online questionnaires. The survey included three parts for occupants: descriptive information, context survey and awareness level. The same three sections were also directed to professionals in the fields of architecture, construction and environmental studies; this was done in addition to a specific section that explored their opinions on the buildability of wind catchers, constraints, costs and possible solutions (Figure 4). The survey was prepared using the Kwick Survey tool, with a

total of 48 questions; most of the questions were closed-ended, to enable later statistical analysis using Microsoft Excel.

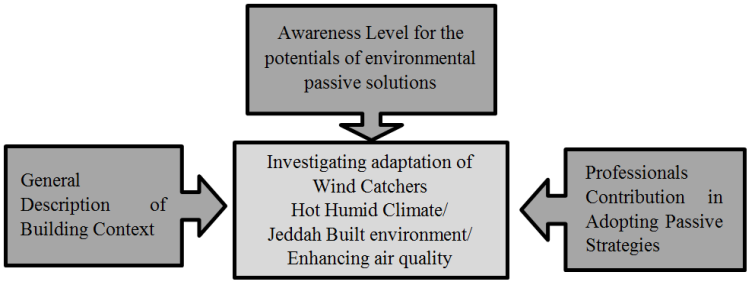

Figure 4
Survey structured questions sections.

Consequently, case study data had to be obtained from a sample that represented the whole population– quality of research not only stands or falls by the appropriateness of methodology and instrumentation, but also by the suitability of the sampling strategy that is adopted (Cohen et al., 2000). There is always a risk with surveys that are intended to measure peoples' attitudes and values– that the respondents may answer misleadingly, known as Response Bias. To avoid response biases in participants, different survey techniques were utilized, including: semi-structured interviews, self-directed questionnaires and online questionnaires. It is therefore important to acknowledge that this survey does not present an objective statement regarding environmental measurements but rather a measure of what respondents perceive as their level of comfort, in terms of existing experiences.

In most cases, it is not possible to survey a whole population, due to time and expense limitations; the critical question is how large the sample should be. Unfortunately, there is no a clear-cut answer to this question; it depends on the purpose of the study and the nature of the population. Many researchers (Drever, 1995; Atkinson, 1971; Cohen et al., 2000; O'leary, 2004), however, have confirmed that a minimum sample size of 30 should be to used to perform statistical analysis on data. To avoid an 'under-coverage' sample, our research employed a total of 109 questionnaires.

There are two main methods of sampling: random sampling and purposive sampling (Cohen et al., 2000). In random sampling, everyone in a population may be included. In purposive sampling, however, the researcher has purposely selected a particular section of the wider population, to include in or exclude from the sample (Mohamed and Gado, 2006). Researchers opted to employ both techniques, in this study, to avoid 'voluntary response' sampling. Purposive sampling was used in choosing the interviewees for selected studies, while the online questionnaire was distributed via social media outlets. Additionally, integrating professionals was relevant, as the survey was directed to re-orient the importance of passive strategies in the construction and architectural context of contemporary developments in Jeddah. This is considerably acknowledging the integration between various

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stakeholders in reforming the expected manifestations in environmental strategies considering improvement of quality of indoor spaces from planning, design till construction and post-occupancy studies. Categories of participants and their respective contributions to research outcomes are shown in Table 1.

Table 1. *Questionnaire Assessment Summary*

	Participants	Outcome
Self-Directed Investigation	Research Team	Descriptive analysis on existing investigated case studies in Jeddah context by site visit and research documentation
Occupants responsiveness	Residents or visitors of Contemporary Buildings within Jeddah context	Level of awareness and responsiveness for indoor comfort levels
Professional Inquiries	Academic researchers and Practitioners	Solutions and progressive elaboration on integrating environmental passive strategies in Jeddah

Survey results

Self directed investigation by research team

This section will present results of the self-directed questionnaire, prepared by the research team. A total of 30 occupants participated: 26.6% were older than 35, 40% were 25–35 years old and 33.3% were below 25. Participants were 20% male and 80% female; 80% of participants were Saudi Arabian and the remaining 20% were foreign. 27% of participants had been residing in Jeddah for over 4 years; 54% were living in the southern regions.

Participants' awareness in terms of indoor air quality enhancement. Most participants stated that high temperatures and humidity levels are the most undesired weather conditions. They also mentioned that most internal spaces in buildings were considerably hot (33%), dusty (28%) and humid (39%). Responses showed that 33% of participants rarely felt comfortable with indoor air quality, while 23% often did; 44% of participants felt this way year round, especially during the winter months. Results also revealed that 38% of the occupants believed spaces that faced main streets or courtyards presented a good opportunity for natural ventilation, while the other spaces had less opportunity. The connections were typical: mostly windows (72%), balconies (14%) and doors (14%). In order to provide isolation from outdoor climate, 23% of residents used curtains and blinds, while 72% of insulation is provided through solid walls. Figure 5 illustrates a percentage of occupants responses, for other questions regarding their beliefs in passive strategies. It is obvious, from the above figure, that the majority of participants favored natural ventilation because of its importance in improving health.

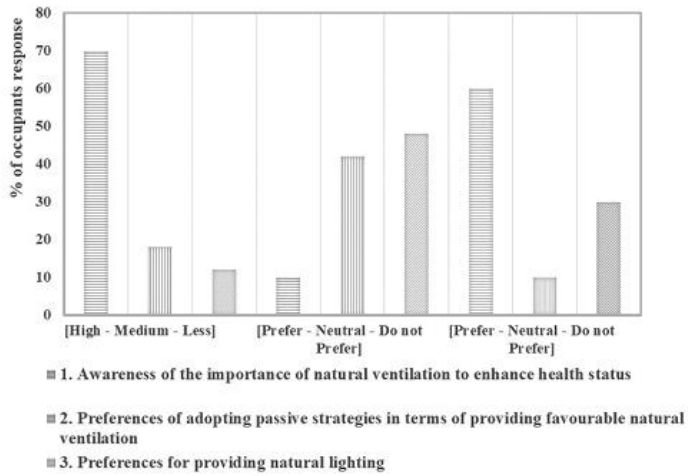

Figure 5
% occupants responses for questions regarding their beliefs in passive strategies

Only 10% of responses indicated that implementing passive measures, such as wind catchers, could provide better ventilation; 60% of participants believed in the importance of natural light inside buildings.

Constraints for passive strategies integration in buildings. The structured questionnaire investigated constraints to applying and implementing a natural passive ventilation strategy, from the perspectives of participants (Figure 6).

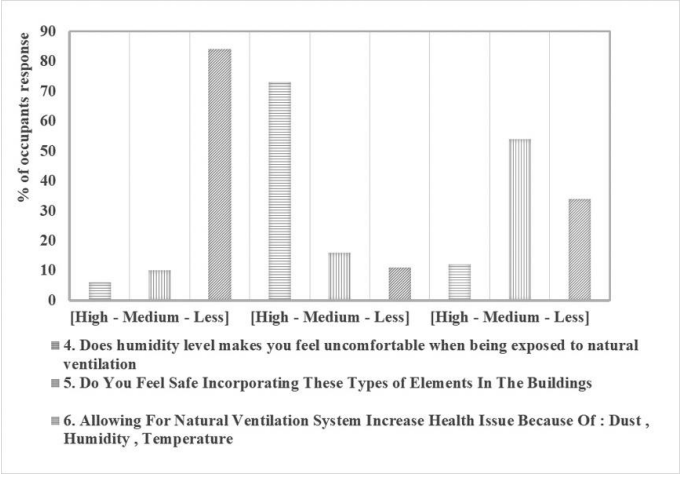

Figure 6
% Occupants responses for questions regarding the constraints of implementing the natural ventilation

It is believed that high levels of humidity, high temperatures, dust and safety issues are the primary reasons for the negligence of such a passive strategy. Responses from participants, however, acted against this hypothesis. Only 6% of participants believed that high levels of humidity could prevent the implementation of a wind catcher in Jeddah. 73% admitted that implementing these passive strategies would

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not compromise the building's safety. Only 12% of participants stated that implementing such strategies could affect human health negatively due to humidity, temperature and dust; 54% did not find a relationship between health issues and natural ventilation, while 34% of participants believed that passive natural ventilation strategies could avoid posing such health issues in buildings.

Professionals and participants survey results

This section will present results of the questionnaire, prepared by the research team and shared online, with relevant participants from professional practices. Selected were professionals in architecture, construction, academic researchers, as well as graduate and undergraduate architecture students. A total of 79 participants responded: 23% were professionals over 35 years old, 35% were students under 23, 35% were 23–35 years old, mostly graduate students and practitioners. 69% of participants were Saudi Arabian and the remaining 31% comprised of Egyptians, Syrians and New-Zealanders. 78% of them had been residing in Jeddah for over 8 years; 64% were living in the Northern regions.

Built Environment Context Description. Participants' responses described the environmental context of specific buildings to be of high standards (33%), medium standards (56%) or of moderate and/or rural standards (11%). The varieties of demographic densities varied from medium density areas (68%), to condensed (13%) and low density/expendable areas (13%). Types of buildings and functional typologies investigated in the survey were: public buildings (6%), residential villas (50%) and apartment buildings (44%); 88% were privately owned and 12 % were publicly/governmentally owned. Building heights were either: three to four levels (52%), two levels or fewer (34%) or five levels and higher (14%). Overall build-environment context for buildings studied was 80% contemporary, 11% heritage/historic and 9% underdeveloped. In terms of durability in build structure, 55% of buildings were viewed as 'excellent', 42% 'good' and 2% were viewed as 'deteriorated'. 81% of buildings were concrete, 6% were steel constructions and 13% used local materials.

Participants' awareness in terms of indoor air quality enhancement. Most participants stated that high temperatures and humidity levels were the most undesired weather conditions. They also mentioned that most internal spaces in buildings were considerably hot (52%), dusty (23%) and humid (21%). Responses showed that 40% of participants rarely felt comfortable with indoor air quality, 30% often did; 5% of participants felt comfortable year round and 19% mentioned winter months provided the most comfortable indoor climate. In residential buildings: 40% of participants mentioned that living rooms had mostly good indoor climate, 28% for bedrooms and 13% for guest areas; 19% mentioned that in the case of air conditioning systems this is not applicable. In public buildings: 53% of participants mentioned that entrance lobbies had mostly good indoor climate and 5% offices did as well; 42% mentioned that in the case of air conditioning systems this is not applicable. Most ventilated spaces overlooked main (34%) and side streets (26%); 36% overlooked courts and 2% of participants claimed this was not

applicable. The connections were typical: windows (63%), balconies (21%), doors (13%), however, 2% reported no openings to the outdoors. In order to provide isolation from outdoor climate, 40% of residents used curtains and blinds and 28% used shutters, while 32% of insulation was provided through solid walls. Figure 7 shows the percentage of occupants' responses, for questions regarding the potential implementation of natural ventilation.

It was noted that 83% of participants were in favor of natural ventilation because of its importance in improving health, however, 70% of the presented buildings did not adopt passive strategies, 26% provided courtyards and only 4% were inclusive of wind catcher formulations. 78% of participants indicated that passive elements could enhance the indoor ventilation, however, 65% believed in the importance of natural light inside buildings.

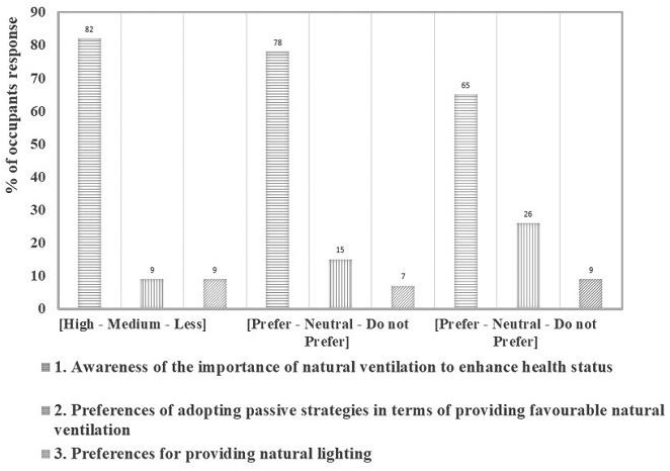

Figure 7
% Occupants responses for questions regarding their beliefs in passive strategies

Constraints for Passive strategies integration in buildings. The structured questionnaire investigated constraints for applying and implementing a natural passive ventilation strategy, from the perspectives of the participants (Figure 8). Only 16% of participants believed that high levels of humidity could prevent the implementation of wind catchers in Jeddah; this also confirms responses of the self-directed questionnaire. 37% of participants confirmed that implementing these passive strategies would not negatively affect safety, while 55% believed that passive natural ventilation strategies could prevent buildings from posing health issues.

The structured questionnaire investigated professionals' views of implementing passive strategies in the initial building design stage, in terms of potential energy savings, initial costs, and technical flexibility (Figures 9).

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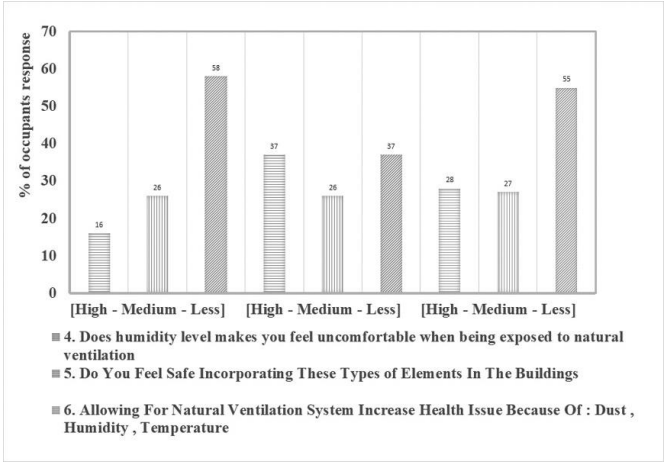


Figure 8
% Occupants responses for questions regarding the constraints of implementing natural ventilation.

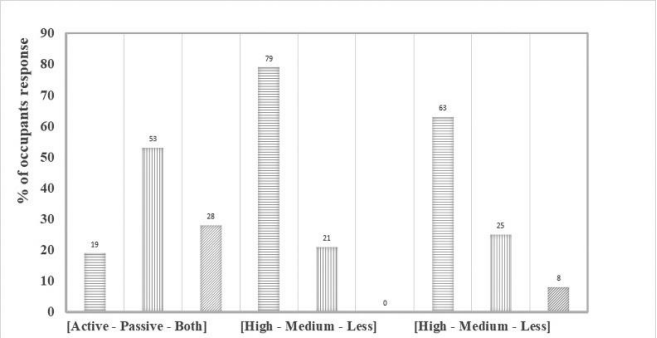
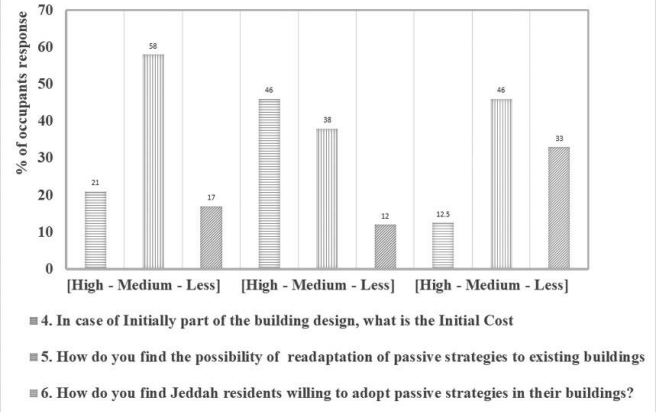


Figure 9
% the potentials of implementing passive strategies integrated in the initial building design.



The results showed that 53% of the professionals were in favor of adapting passive strategies in buildings, 28% preferred to adapt both passive and active strategies, while only 19% did not prefer to adapt passive strategies in existing buildings. While the majority (79%) was in favor of adapting passive strategies in the early stages of design, 63% confirmed their awareness of positive effects of this approach, in energy savings. 58% of participants confirmed that the cost of such strategies was affordable. The last two questions regarded their professional perspectives on the potential of implementing passive strategies in Jeddah with their clients; 46% asserted high potential with clients, of convincing them to adopt passive strategies in new designs.

Conclusion and Recommendations

This paper was concerned with investigating the potential revival of wind catcher use in Jeddah, as one of the most important passive measures to significantly enhance natural ventilation, thus also enhance human comfort. 109 detailed questionnaires were conducted; 30 were self-directed questionnaires with residents and 79 were online questionnaires. 24 questionnaires were filled by professionals.
The results showed a high level of awareness, among participants, about the importance of natural ventilation inside buildings. Professionals asserted a direct relationship between passive strategies, particularly the wind catcher and natural ventilation, however, only 10% of residents could see this relationship.

Table 2. *Potentials and Constrains of Integrating the Wind Catcher in Jeddah's contemporary Residential Buildings*

Potentials	*Constrains*
Great potential of the integration of PSM in building design	Difficulty of the adaptation of PSM in existed buildings
The majority of the participants do not consider humidity, dust, and health issue are constrains of adapting natural ventilation strategies	Level of awareness of passive techniques (Most importantly – Wind Catcher) and its relationship with the natural ventilation
Level of awareness of the importance of natural ventilation	Air-condition system and its conflict with natural ventilation
Level of awareness of the relationship between PSM and Energy consumption	
Enthusiasm of professional to convince clients by passive strategies and measures	

*Passive Strategies and Measures (PSM)

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Therefore, it is important to raise awareness among locals, of such passive strategies. The majority of participants also confirmed that issues such as: health issues, humidity, dust, and high temperatures should not prevent the implementation such useful strategies.
The majority of participants preferred to adapt passive strategies in the designs of new buildings, while they confirmed the difficulty of adapting these strategies in existing buildings; any modifications for existing buildings would cost money and time, plus expected results are not clear for clients. In addition, they confirmed that costs associated with passive strategies are considered reasonable, in the case that they are implemented in the early stages of design. Table 2 summarizes important potentials and constraints of integrating the wind catcher in Jeddah's contemporary residential buildings.

Future work

This research paper acquired detailed analysis of indoor spaces relevant to natural ventilation, passive strategies and special experiences. Further technical experiments and assessments are being conducted, in specific contemporary buildings/physical models, as part of the overall research proposal.

Acknowledgments

This paper contains the results and findings of part of an on-going research project, funded by the King Abdul-Aziz City for Science and Technology (KACST) Grant No. (*334-37-م ص*). It aims to investigate the potential of modifying the wind catcher and addressing climate-related aspects of Jeddah City. The authors would like to thank the research team their support, especially: Dr. Mohamed Fekry, Dr. Sameer Felmban and Arch. Zeina Beydoun.

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INTÉGRATION DE WIND CATCHER DANS LES BÂTIMENTS CONTEMPORAINS À DJEDDAH

Résumé

La ville de Djeddah est une zone chaude et aride caractérisée par des températures et une humidité de l'air élevées. Une nouvelle architecture doit être entreprise en essayant de réaliser le paradigme de la ventilation naturelle et les initiatives doivent viser à minimiser les effets néfastes d'un environnement hostile sur les habitants de la ville (Mohamed et Fekry, 2018). Cet article se concentre sur les raisons de la négligence de l'utilisation du capteur de vent dans les bâtiments résidentiels contemporains de la ville de Djeddah. Il emploie des entretiens semi-structurés et des questionnaires avec les résidents et les professionnels pour illustrer leurs opinions. Les résultats montrent un manque relatif de sensibilisation chez les résidents concernant les stratégies passives dans leur ensemble et les capteurs de vent, en particulier. Les résultats montrent également un potentiel tangible parmi les professionnels pour adapter des stratégies et des outils passifs. Plus important encore, cet article tente d'illustrer en quoi les résultats de l'enquête sont contraires aux idées reçues: les niveaux élevés d'humidité, de température, de poussière et de sécurité sont les principales raisons de la négligence des stratégies de ventilation naturelle à Djeddah.
Mots clés: *capteur de vent, stratégies et mesures passives, interventions patrimoniales, évaluation subjective*

SULL'INTEGRAZIONE DI WIND CATCHER NEGLI EDIFICI CONTEMPORANEI A JEDDAH

Riassunto

Jeddah City è una zona calda e arida ed è caratterizzata da alte temperature e umidità dell'aria. La nuova architettura dovrà essere intrapresa cercando di raggiungere il paradigma della ventilazione naturale e le iniziative dovrebbero mirare a ridurre al minimo gli effetti nocivi di un ambiente ostile per gli abitanti delle città (Mohamed e Fekry, 2018). Questo documento si concentra sulla ricerca di ragioni dietro la negligenza dell'uso di collettori di vento, negli edifici residenziali contemporanei, nella città di Jeddah - che impiega interviste semi-strutturate e questionari con residenti e professionisti, per illustrare le loro opinioni. I risultati mostrano una relativa mancanza di consapevolezza tra i residenti in merito alle strategie passive in generale e ai rilevatori di vento, in particolare. I risultati mostrano, tuttavia, il potenziale tangibile tra i professionisti di adattare strategie e strumenti passivi. Soprattutto, questo documento tenta di illustrare come i risultati del sondaggio risultino contrari alla convinzione convenzionale che alti livelli di umidità, temperatura, polvere e problemi di sicurezza siano i motivi principali che inficiano le strategie di ventilazione naturale a Jeddah.
Parole chiave: *collettore di vento, strategie e misure passive, interventi sul patrimonio, valutazione soggettiva*