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Towards a Green Building: A Preliminary Study of Natural Ventilation on Thermal Comfort and its Impact on Residential Building in the City of New Borg El Arab

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ABSTRACT

Natural ventilation considered a one of challenges of the green building design.
This paper introduces a preliminary study for measuring the extent of natural ventilation on thermal comfort to the impact of indoor air quality in the residential building in the city of New Borg El Arab (Egypt-Japan University of Science and Technology, E-JUST as example) in relation to air velocity, relative humidity, and air temperature. New Borg El Arab climate in the site location is semi-arid Mediterranean climate, this type of climate is characterized by a brief, mild, moderate rain in winter and long warm summer months with no rain. To apply this study, a methodological procedure has been followed. A field study is conducted in a one flat from the building of the E-JUST to assess the indoor thermal conditions based on adaptive standard comfort model during the month of climate change (October through 3 experimental measuring 1st, middle, and last of the month). The indoor measured data of air temperature, air velocity and relative humidity were used to check if the apartment that choose as a case study complies the thermal comfort or not by using ASHRAE psychrometric chart. Personal observations, field measurements and ASHRAE psychrometric chart analyses show that there is significant thermal discomfort inside the domain. The results indicated that the indoor air quality in many of the cases didn't achieve the thermal comfort for most time. This is because there is no circulation for natural ventilation in this orientation of the domain.

1. INTRODUCTION

New Borg El Arab city, located at Latitude 30.9008891 and Longitude 29.5509462. It is situated around 45 kilometers south-west Alexandria downtown area and somewhere in the range of seven kilometers from the Mediterranean coast. North of the New Borg El Arab city is King Marriott resort and Marriott Lake, the atmosphere in the site area is semi-dry Mediterranean atmosphere. This kind of atmosphere is described by a brief, gentle, moderate downpour in winter and long warm summer months with no downpour. [1]. The monthly mean values of

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air temperature are shown in Table 1; the variation of the monthly mean air temperature indicates a range from 14.1 ºC in January to 31.5 ºC in August. The relative humidity typically ranges from 45% (comfortable) to 92% (very humid) over the course of the year, rarely dropping below 28% (dry) and reaching as high as 100% (very humid) [2]. Over the course of the year typical wind speeds vary from 0 m/s (light air to moderate breeze), rarely exceeding 11 m/s (strong breeze). The highest average wind speed of 5 m/s (gentle breeze) occur around July, at which time the average daily maximum wind speed is 7 m/s (moderate breeze), and the prevailing wind direction is strongly affected by the North-Western [3]. Figure 1; depict the wind roses for all months of the year. The wind is most often out of the North West (28% of the time) and north (23% of the time). The wind is least often out of the south east (4% of the time) and south west (4% of the time).

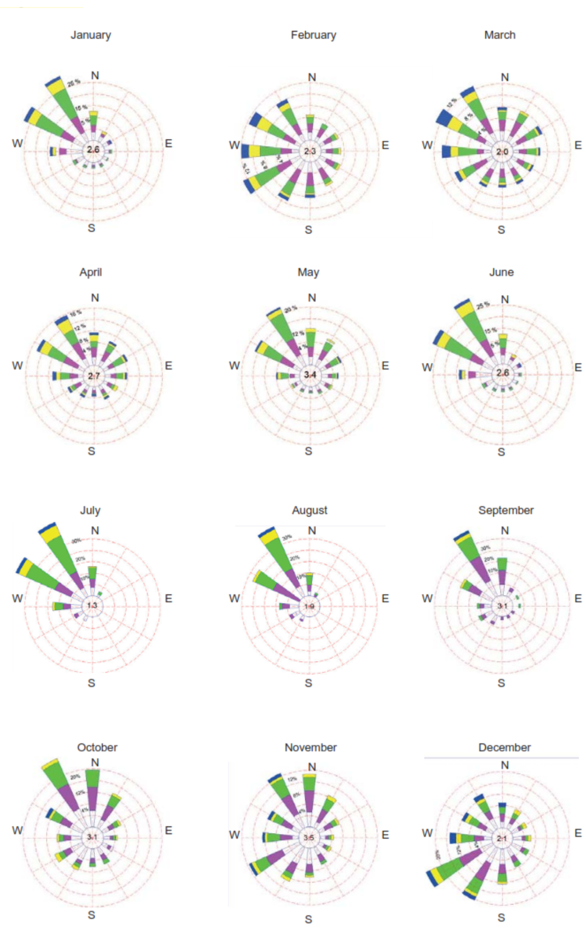

Fig. 1. Wind rose monthly at Borg El Arab

Table 1. Mean monthly temperature at New Borg El Arab city

Month	Mean Temp. (ºC)	Month	Mean Temp. (ºC)
January	14.1	July	29.9
February	16	August	31.5
March	16.7	September	25.2
April	17.7	October	23
May	21.5	November	19
June	25.9	December	15

To accomplish instant thermal comfort conditions, air conditioning systems are widely used in residential buildings. However, these systems are energy expensive. Regular ventilation is, then again, a more vitality efficient distinct option for give satisfactory solace a significant decrease in vitality utilization by mechanical cooling frameworks. With this concern, there are various natural ventilation strategies to improve thermal comfort that have been proposed and investigated [4-8]; also, comfort ventilation has been suggested as the best uninvolved cooling technique for hot-damp atmospheres [9].

This study introduces a preliminary study for measuring the extent of natural ventilation on thermal comfort to the impact of indoor air quality in the residential building in the city of New Borg El Arab in relation to air velocity, humidity, and temperature. To achieve this objective, a methodological procedure has been followed. A field study is conducted in a one flat from the buildings of E-JUST to assess the indoor thermal conditions based on adaptive standard comfort model during the month of climate change (October through 3 experimentally measuring 1st, middle, and last of the month).

The indoor measured data of air temperature, air velocity and relative humidity were used to specify the comfort compromising of the apartment as a case study by using ASHRAE psychrometric chart. Personal observations, field measurements and ASHRAE psychrometric chart analyses show that there is significant thermal discomfort inside the apartments.

2. BACKGROND

Dominating the indoor environment can have significant impacts on both enhancing comfort and reducing energy consumption [10]. It is generally hard to get thermal comfort inside buildings due to the complexity of the contributing components choosing whether the conditions being referred to will make individuals feel discomfort or not. It is generally agreed that variables influencing thermal comfort inside structures can be assembled into two gatherings; human components and environmental factors. The environmental factors include air temperatures, air velocity, mean radiant temperature and relative humidity [11].

Air temperature, is the most regularly utilized marker of thermal comfort [12] and is thought to be the most imperative component deciding warmth stress. Mean brilliant temperature which is dictated by the temperature of the encompassing surfaces is likewise a significant element adding to thermal comfort. Also, the relative humidity is another important factor affecting thermal comfort, where high levels of humidity inside buildings prevent the evaporation of sweat from skin; the main method human body losses heat [13]. In hot climates this could have a significant effect on the thermal comfort. Dehumidifiers [14], heat and ventilation are the best way to reduce humidity levels.

3. METHODOLOGY

3.1. Case Study

The study was conducted in New Borg El Arab city; coordinates: 30°51'37"N, 29°34'29"E. It is one of the new urban areas whose foundation is commanded in the national arrangement of the Arab Republic of Egypt for the foundation of new urban groups, with the point of retaining the present and future ascent in populace in the city of Alexandria and of putting a conclusion to the utilization of horticultural area for building. The city is surrounded on all sides by a green belt with a surface area of 18,000 acres. As a residential-industrial city with a full range of utilities and services, New Borg El Arab is regarded as a major urban center [15]. Figure 2, illustrated the location of the city.

The building chosen for this study is a newly built that consists of five floors divided into twenty prototype apartments with an equal area of 63 m2 for each apartment, which is the campus of Egypt-Japan University of Science and Technology. E-JUST campus is located in the new Borg El-Arab city, near Alexandria, Egypt.

The campus as appeared in Figure 3 comprises of fourteen structures. Every building has a tallness of 17m and its geometry and measurements are as outlined in Figure 4. The campus building array is making an angle of 37o with north. The buildings are oriented and designed irrespective of the bioclimatic conditions. The building was analyzed based on a visual survey and desktop study for the as built drawings. The skeleton structure for the buildings is made completely of strengthened cement both for pieces and segments, red blocks with openings of measurements 250 x 120 x 60 mm were utilized for the inward and outside dividers with bond putting covering thickness of 12mm and no protection is utilized.

Fig. 2. Borg El Arab location

Fig. 3. Case study location and perspective view

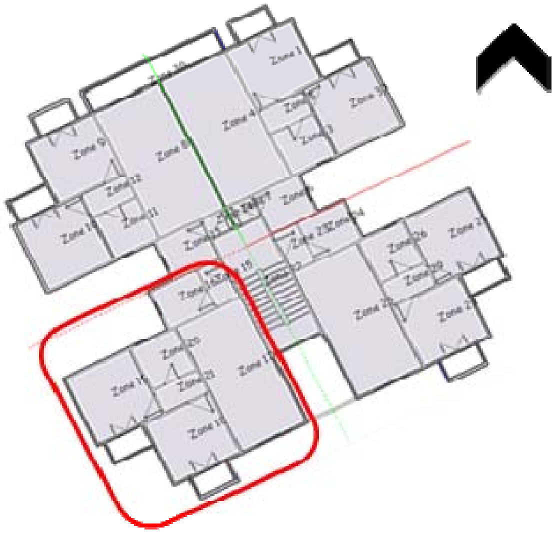

Fig. 4. Geometry of one building of E-JUST

3.2. Measurements

The field measurements were performed over six days two times per day (at mid-day, and mid-night) during three periods of the October month; where this period of time in Egypt is considered a climate change, the end of the hot weather condition season and the beginning of moderate weather condition season. The three periods are arranged as the following: the 1st one includes the 3rd and 4th day of the month, the 2nd period taken in the middle of the month which includes the days 15th and 18th, and the last period includes the last days of the month that includes the 29th and 31th October, 2015. The measurements are taken during the closed doors and the open doors.

The measurement is taken on the third floor that lies in middle of the building, to take into account it is far away from the impact of the resulting degrees of surface temperature as a result of solar radiation. The housing unit was divided into modular network for measuring, which includes 12 points, P1, P2,…, P12 as shown in Figure 5. Every point measured twice within 5 minutes during the mid-day and the same at the mid-night, and from 1 m of height from the ground.

In this field of study, VelociCalc® Air Velocity Meter 9545-A is used for measuring and recording, see Figure 6. This meter all the while measures and information logs a few ventilation parameters utilizing a solitary test with various sensors.

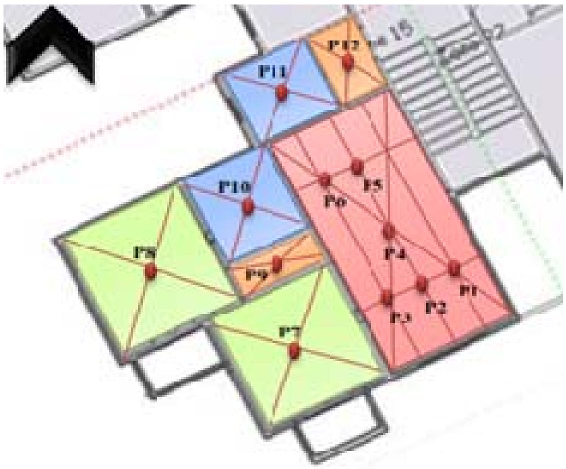

Fig. 5. Network module for 12 measuring points of the apartment

Fig. 6. Air velocity meter 9545-A and the field of study

It measures velocity, temperature, and relative humidity; and calculates flow, wet bulb and dew point temperature.

The device measured and recorded the data values every minute and the average of each 5 minutes was determined and is presented in the results section. In addition, outdoor climate data were obtained from the meteorological records of the nearest regional weather station (WMO 62301) for the same period [16], to choose the days of measurements.

4. RESULTS AND DISCUSSION

4.1. Measured Data

The measurements have been carried out inside all the spaces of the apartment that contain the 12 points in the 3rd floor level. The indoor air temperature (T_{in} ºC), air velocity (Av m/s) and relative humidity (RH %) were monitored in one hour intervals during mid-day and mid-night for two days of 1st month, 2 days in the middle of the month, and also 2 days at the last of it. All the measured data were taken in natural ventilation during two different cases, the first case when the doors are closed and the second case when the doors are opened except the windows were always opened in the two cases.

Figure 7 (a, b) shows average results in the field measurements for three parameters, which includes air velocity, relative humidity and air temperature in the indoor of the case study apartment. The results showed that the measurements, which were taken during the middle hours of the day in case of the closing of the doors and open windows to provide natural ventilation, explained that measure air velocity at all points almost zero and temperatures ranging between 26 and 33 degrees Celsius and humidity ranging between 56 and 64 percent.

Also, in case of opened all the doors and windows except the main door of the apartment, the same measurements occurred. The all three parameters of measurements in case of closed and opened doors are very convergent from each other. So, the measurements showed that there are no air circulations in the space of the apartment and the thermal comfort is not achieved in this case.

4.2. Thermal Comfort Assessment

In this study, a method was employed to assess the thermal comfort inside the case study using the CBE Thermal Comfort Tool (Centre for the Built Environment), which is an online tool for evaluating comfort according to ASHRAE Standard-55 [17]. The tool is used to predict comfort in naturally ventilated spaces. The CBE Tool allows users to input six comfort parameters (air temperature, mean radiant temperature, Air speed, humidity, metabolic rate, and clothing level) to determine whether a certain combination complies with ASHRAE 55. The results are displayed on a psychrometric chart and indicate the region of temperature and relative humidity that will be comfortable or not with the given values input for the all parameters [18].

The thermal comfort is depicted on the CBE tools as shown in figure 8, where the measurements were taken as average of the 12 points. Figure 8 (a) represents the thermal comfort for the 3 days from left to right in case of closed doors (1st, middle, and last) of the month. It is cleared from the figure that in case of 1st and middle of the month thermal comfort didn’t complied with ASHRAE, but the last is complied with comfort because the measurements were taken in the last of October month, which it is considered the climate changed from summer to winter. The analysis for the rest of figures (b, c, and d) is as in case of (a). So, from the analysis of figure 8, it is cleared that the thermal comfort did not complied over all the summer period, which includes the months from June to October.

5. CONCLUSION

This paper was concerned with the objective of thermal comfort assessment inside the apartment that used as a case study for E-JUST buildings that built in the hot desert climatic region of New Borg El Arab, Alexandria, Egypt. All factors affecting thermal comfort were monitored and analyzed.

The CBE tool for thermal comfort assessment was used to calculate the comfort air temperature, air speed and the relative humidity. The results summarized that the indoor air quality for all the cases did not complied with the thermal comfort for most of the time. This is because there is no a good circulation for natural ventilation in this orientation in the design of the apartment.

6. FURTHER WORK

Further work will examine methods for improving the indoor air quality execution if there should be an occurrence of normal ventilation of the model utilized as a part of E-JUST structures. A simulation based study is under approach to evaluate the adequacy of various parameters and systems used to improve the execution of the run of the mill configuration of structures.

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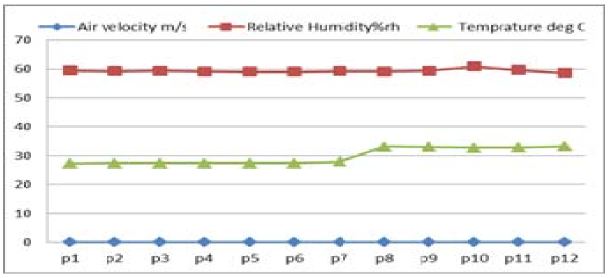

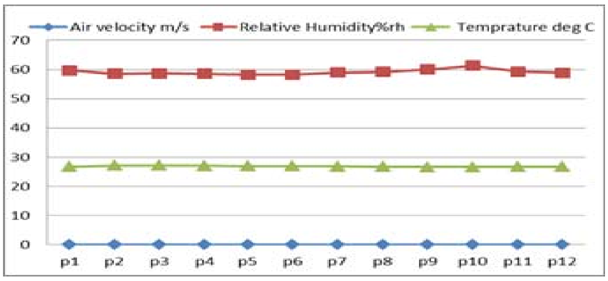

(a) closed doors over the 6 days (b) opened doors over the 6 days

Fig. 7: Average of measurements (a) closed doors (b) opened doors

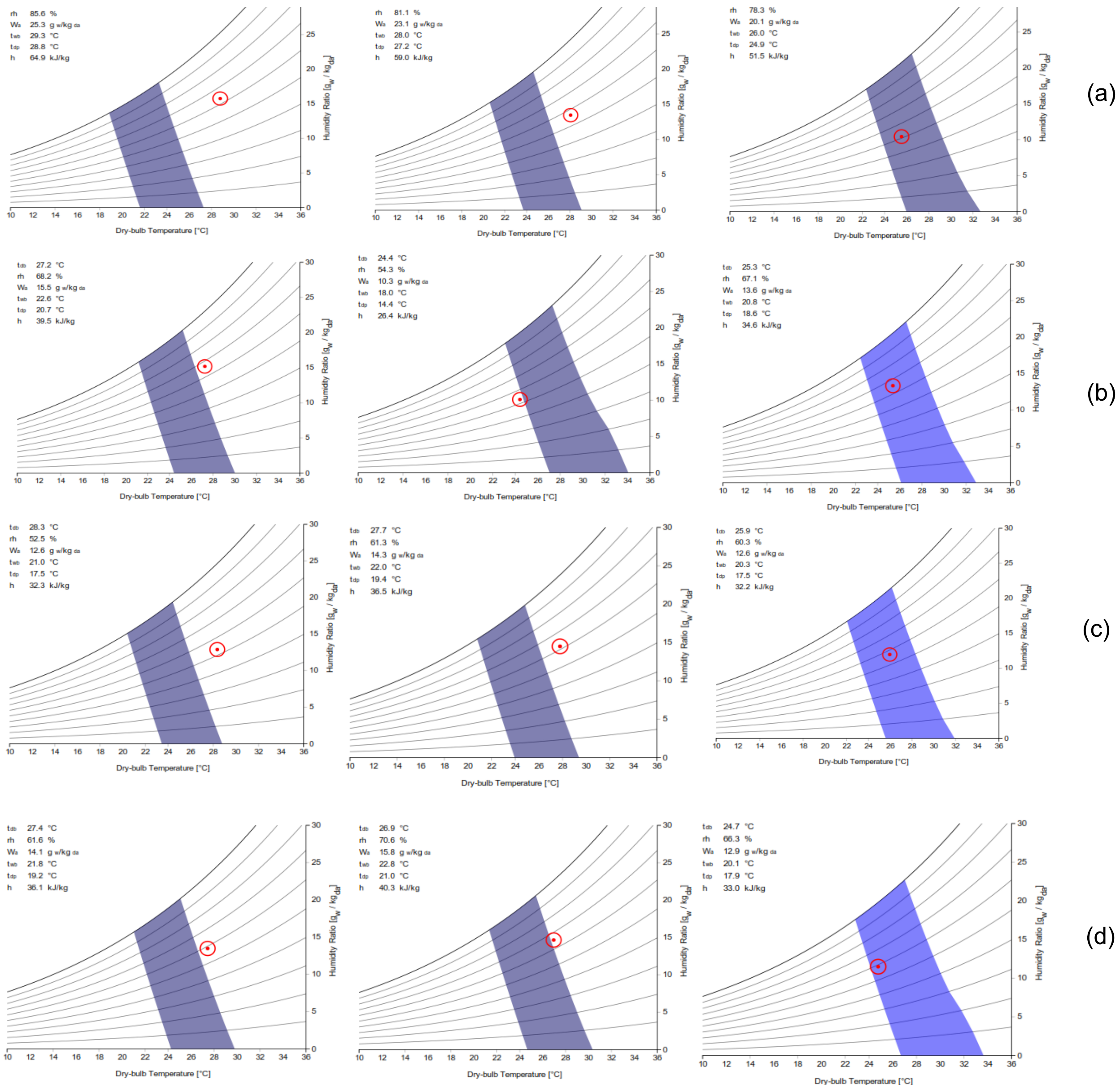

Fig. 8: Thermal comfort comparison among the six days in mid-day and mid-night apartment (from left to right) (a) 3 days at mid-day with closed doors (b) 3 days at mid-night with closed doors (c) 3 days at mid-day with opened doors (d) 3 days at mid-night with opened doors

References

[1] S. Khaled and M. Soad, “On the relation between cloud cover amount and sunshine duration”, Journal of Meteorology and Atmospheric Physics, Springer, Vol. 87, pp. 235–240, 2004.

[2] Egypt - Japan University Of Science and Technology, Alexandria, Egypt, Final Draft Masterplan Report, 2013.

[3] https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine, Alexandria, Egypt, last accessed: November 1, 2015.

[4] L. Wang and NH. Wong, “Applying natural ventilation for thermal comfort in residential buildings in Singapore”, Architectural Science Review, Vol 50, pp. 224e33, 2007.

[5] S. Chungloo, B. Limmeechokchai, “Application of passive cooling systems in the hot and humid climate: the case study of solar chimney and wetted roof in Thailand”, Build Environ, Vol 42, pp. 3341e51, 2007.

[6] P. Vangtook, S. Chirarattananon, “Application of radiant cooling as a passive cooling option in hot humid climate”, Build Environ, Vol, pp. 42:543e56, 2007.

[7] E. Dascalaki et al, “Predicting single sided natural ventilation rates in buildings. Sol Energy, Vol 55, pp.327e41, 1995.

[8] J. Khedari, “Ventilation impact of a solar chimney on indoor temperature fluctuation and air change in a school building”, Energ Buildings, Vol 32, pp. 89e93, 2000.

[9] K. Papakonstantinou, “Numerical simulation of air flow field in single-sided ventilated buildings”, Energ Buildings, Vol 33, pp. 41e8, 2000.

[10] G. Brager and D. Dear, “Thermal adaptation in the built environment: a literature review”, Energy and Buildings, Vol. 27, pp. 83-96, 1998.

[11] A. Sedki, “Effect of Orientation on Indoor Thermal Neutrality in Winter Season in Hot Arid Climates Case Study: Residential Building in Greater Cairo”, International Journal of Engineering and Technology, Vol. 5, 2013.

[12] W. Yang, "Effect of Street Design on Outdoor Thermal Comfort in an Urban Street in Singapore" J. Urban Plann, Vol. 141, pp. 1-19, 2015.

[13] J. Elson and S. Eckels, “An objective method for screening and selecting personal cooling systems based on cooling properties”, J. Applied Ergonomics, Vol. 48, pp. 33–41, 2015.

[14] http://aetinc.biz/newsletters/insights/march-2010, last accessed: October 31. 2015.

[15] http://en.wikipedia.org/wiki/Borg_El_Arab, last accessed: October 31. 2015.

[16] http://climexp.knmi.nl/getprcpall.cgi?id=someone@somewhere&WMO=62301&STATION=SIDI_BARANI&extraargs, last accessed: November 1, 2015.

[17] http://comfort.cbe.berkeley.edu, last access: November 1, 2015.

[18] HVACR training authority, “The Psychrometric Chart and Its Use”, Service Application Manual SAM Chapter 630-16 Section 3A, pp. 1-23, 2009.