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Studying the Effect of Zone's Volume to Area Ratio (V/A) on its Energy Cycle in Yazd, Iran Hot-Arid Climate

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Abstract: This study starts with this question that is there any correlation between the volume to area ratio of a space and its interior thermal conditions and if answer is yes, how it can affect the energy cycle in that space and what aspects of interior heat, energy and comfort conditions would be affected? The BIM based software simulation based on existed case method being chosen as methodology of research and The Ecotect^{TM} 5.5 Software being chosen to model, simulate and investigating previously mentioned issue. Researchers model two zones of Mortaz traditional house in hot dry climate of Yazd in Iran as case study of this research. Results showed that there is a correlation between volume to area ratio of a space and its energy cycle. With increase of volume/area ratio, the fluctuations of thermal balance of interior space and parameters like variance of maximum and minimum temperature of space and total energy consumption increased both in seasonal periods and also in just single daytime.

Key words: Volume to area ratio, energy cycle, thermal mass, BIM Software, Ecotect^{TM}, zones

INTRODUCTION

This research takes two parameters as independent parameters and study effect of the ratio between a room and space's Volume (V) and its Area (A) on energy cycle, thermal fluctuation and of that space or room. For reaching this aim, there was some available frameworks that researchers of this study decide to take case study with software simulation approach that may help more to get most close results.

For choosing best case, a comprehensive study been done and finally, Mortaz traditional house in hot and dry climate of Yazd being chosen. There was some criteria for choosing best case which some features of Mortaz house fulfil these criteria. One, this private court yarded house from Qajar period have rooms with relatively same size and climatic similarities like same orientation, material, total surface/total exposed surface and total exposed/total windowed surface that make them more comparable. Second, the case being chosen from Yazd in hot dry desert climate which not only challenge the building through seasonal climatic changes but also because of big difference of day and night temperature in a single day, it gives researches to see and compare more data changes through simulation. As traditional buildings from these periods of time, built with massive, masonry walls, the amount of fabric gain which can decrease fluctuations of thermal balance in interior spaces, the data taken from simulation can be prorate and results can be interpreted with more accuracy that makes third result for choosing this building as case.

EcotectTM V 5.5 used for modelling and also thermal simulation of this research. This software gives vast facilities for correct modelling and also had much of adjustments for taking most accurate desirable results for intended tests. In this research, hourly temperature profiles, annual temperature distribution and passive heat gain and lose breakdown figures and data being instructed and used for achieving conclusions.

Literature review: The existing buildings stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) member states, of which residential use represents 63% of total energy consumption in the buildings sector. Consequently, an increase of building energy performance can constitute an important instrument in the efforts to alleviate the EU energy import dependency and comply with the Kyoto Protocol to reduce carbon dioxide emissions. This is also in accordance to the European Directive on the Energy Performance of Buildings (EPBD) which has come to effect on 4 January 2006 (Poel *et al*., 2007).

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In the most countries, the residential energy consumption has allocated a large percentage of national energy consumption to itself. In Iran, the portion of residential sector in energy consumption is 37% having the most portion compare with other sectors as shown in. On the other hand, in the recent years the energy consumption in housing unit has increased in Iran and it has been doubled during 1998-2008 as shown in. The diverse factors have impacted in residential energy consumption such as the population growth, economical performance, consumer taste, technological developments and the building style (Faizi *et al*., 2011).

Now a days materials with high thermal inertia and less weight or mass are produced and used in building industry and using massive bodies of materials like brick or stone like what had used in most traditional buildings of past is not logical because in one hand height of buildings going high and using massive materials make them more heavier and creates structural issues and in other hand materials like brick or stone which are more bulky and occupies more space, so there's more need for materials that have less weight and less thickness or materials that have especial thermal characteristics like that PCM materials with high latent heat being introduced and developed in recent years (Alawadhi, 2008; Oliver, 2012; Pasupathy and Velraj, 2008; Zalba *et al*., 2003; Zhang *et al*., 2011; Zhou *et al*., 2012). Some of studies on the effect of material's latent heat on interior space conditions can be found in these fields (Hasnain, 1998; Hawes *et al*., 1993; Khudhair and Farid, 2004). Also there is a vast range of studies that merely investigate the effect of thermal mass on interior comfort conditions and qualities (Al-Sanea *et al*., 2012, 2013; Balaras, 1996; Braun, 2003; Dodoo *et al*., 2012; Gilbert and Kissock, 2007; Gregory *et al*., 2008; Kalogirou *et al*., 2002; Karlsson, 2012; Kosny *et al*., 2001; Ogoli, 2003; Ruud *et al*., 1990; Yang and Li, 2008; Yilmaz, 2007; Zeng *et al*., 2011; Zhu *et al*., 2009).

Most of studies and papers related with climatic designs, being done in different climatic zones in different countries and cities and each of them studied the effect of different parameters on interior conditions. For example, it can be found studies that investigate the effect of thermal mass, U-value or latent heat in hot arid climates (Al-Sanea and Zedan, 2002; Ali-Toudert and Mayer, 2006; Askar *et al*., 2001; Cena and de Dear, 2001; Hashemi *et al*., 2010; Johansson, 2006; Lavafpour and Surat, 2011; Masmoudi and Mazouz, 2004; Mlakar and Strancar, 2011; Porta-Gandara *et al*., 2002; Ratti *et al*., 2003; Raychaudhuri *et al*., 1965; Saeed, 1996; Sedki *et al*., 2013) and also for other types of climates studies being undertaken and can be cited too (Badescu and Sicre, 2003; Heidari and Sharples, 2002; Raman *et al*., 2001; Skibin and Noach, 1982; Yu *et al*., 2008).

As it is being mentioned, most of traditional Iranian houses being built with materials with high thermal mass and low U-value and authors aimed to study the effect of these factors on actual architectural interior, not hypothetical models. This study's cases are traditional Iranian houses which all of them are built around 100-200 years ago and from Quajari period. But the essence and the main approach of this study is the comparison of the U-value effect on interior space conditions in two cities with different climatic characteristics: Yazd which is one of most hot and arid cities of Iran and Tabriz which on the contrary has one of the coldest climates of country. For this more than twenty traditional houses both in Tabriz and Yazd being studied to find best comparable cases which has most spatial, architectural and climatic characteristic likeliness that their comparison can give the researchers creditable results. The aim for this study was to compare and conclude that in which climatic zone, U-valve has more direct and dominant effect on interior space's comfort conditions.

The current reality and future threats of climate change, constrained natural resources and infrastructure and increasing urbanization are forcing many world governments to quantify the impact that our built environment is having on these challenges. This has led to the identification and implementation of regulatory measures intended to change the way we design, construct and operate buildings in order to reduce their negative impacts (Miller *et al*., 2012).

Energy performance and indoor environment have become increasingly important in building design. Building developers and designers are straining to produce buildings with low energy consumption and high indoor environmental performance. The energy a building consumes for its operation and maintenance is directly linked to amount of its carbon emissions. This attention to energy performance has led to a growing awareness that in order to achieve low energy buildings with satisfactory indoor climate, the designer must be aware of the consequences of critical design decisions as early as possible in the design process (Vangimalla *et al*., 2011).

In developed countries people spend >90% of their time indoors. Indoor conditions have therefore far-reaching implications for their health, general well-being and performance. Numerous studies have explored how building users perceive the indoor environment and which conditions are considered to be comfortable. In indoor environments, a number of physical and chemical parameters have been identified that influence the comfort of building occupants. Standards dealing with indoor environmental quality have been developed to define the acceptable ranges of these parameters. One obvious reason is that people differ and therefore not all are satisfied by the same conditions. Another reason could be that not only physical conditions influence satisfaction with indoor environments. There may also be other factors, unrelated to environmental quality that influence whether indoor environments are considered to be comfortable or not; these factors are usually not regulated by the standards (Frontczak and Wargocki, 2011).

With the need for sustainability generally recognized in higher education and relatively mature, usable whole-building simulation software available, the question needs to be asked why, despite these efforts, design-intrinsic, robust evaluation tool use in education and professional studios is apparently still rare. Unfortunately, a globally representative study of adoption rates in fundamental architectural education is not currently available; however, if one regards the apparent picture in practice, there emerges a tentative hint that internationally, only a low percentage of schools appears to be consistently pursuing an approach that provides a critical mass of students with design-driven, robust environmental performance evaluation skills (Doelling and Nasrollahi, 2013).

Also ECOTECT Version 5.50 is a highly visual architectural design and analysis tool that links a comprehensive 3D modeller with a wide range of performance analysis functions covering thermal, energy, lighting, shading, acoustics and cost aspects. Whilst its modelling and analysis capabilities can handle geometry of any size and complexity, its main advantage is a focus on feedback at the earliest stages of the building design process (Crawley *et al.*, 2008).

MATERIALS AND METHODS

Two rooms in two different courtyard of Mortaz house with same orientation and relatively same features been modelled as Zones No. 1 and 2. The exact dimensions and features of both being mentioned below. The thermal analysis being applied. The zones properties for thermal analysis were same except for dimensions that as said before was our independent variable. In both, types of materials used in walls, floors, windows, doors and etc., chosen same. Temperature analysis was conducted in both mainly but other analysis like annual temperature distribution and passive heat gain and loses breakdown helped to getting more accurate results and conclusion in overall.

- Basic information about Zone No. 1
- 0000 Zone No 1
- Floor area: 56.792 m^2
- Volume: 327.857 m^3
- Total surface area 388.023 m^2 (683.2% flr area)
- Total exposed area: 200.429 m^2 (357.7% flr area)
- Total window area: 12.829 m^2 (22.5% flr area)

As shown, these two zones have the relatively same width of 5.8 and depth of 9.5. Also their windowed exposures are both to their courtyards, face to southeast. Apart from a slight differences in dimensions of these two rooms (or Zones), there is just one major difference between them which Zone No. 1 has an initial colonnaded wall that separate the room to two smaller spaces. This difference make the total surface area of this space more and create more mass (or "Fabric") that affect total "Fabric Gains" of this space more. More detailed information about these two zones:

Detailed informations of Zone No. 1:

- Zone No. 1
- Floor area: 56.792 m^2
- Volume: 327.857 m^3
- Total conductance (AU)/total area (AU/U = U) = 9.5
- Volume/Area (V/A) 5.7
- Total surface area area (AS/A) = 6.22
- Total surface area: 388.023 m^2 (683.2% flr area)
- Total exposed area: 184.429 m^2 (357.7% flr area)
- Total window area: 10.829 m^2 (22.5% flr area)
- Total conductance (AU): 530 W/°K
- Total admittance (AY): 1819 W/°K
- TSA/A = 6.92
- TSA/V = 1.87

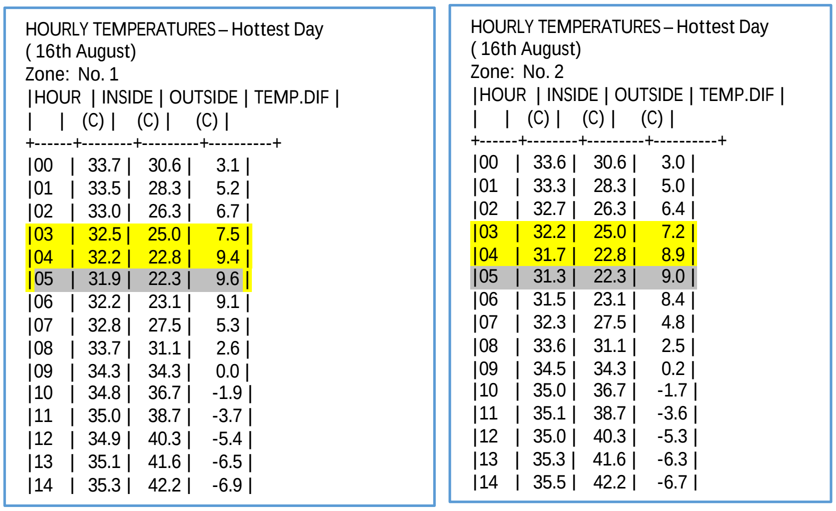
Detailed informations of Zone No. 2:

- Zone No. 2
- Floor Area: 55.588 m^2
- Volume: 330.595 m^3
- Total conductance (AU)/total area(AU/U = U) = 10
- Volume/Area (V/A) = 6
- Total surface area/area (AS/A) = 5.83
- Total surface area: 321.222 m^2 (577.9% flr area)
- Total exposed area: 201.072 m^2 (361.7% flr area)
- Total window area: 12.867 m^2 (23.1% flr area)
- Total conductance (AU): 565 W/°K
- Total admittance (AY): 1514 W/°K
- TSA/a = 5.83
- TSA/V = 0.972

RESULTS AND DISCUSSION

The first tables that was needed to compare, was hourly temperatures profile. These tables can be extracted for any days of year. But also there is some specific days like hottest, coldest, most windy and etc. days. We compare inside and outside hourly temperature tables of hottest and coldest day to having a better understanding about zones thermal behaviour.

It can be seen that in coldest hours of hottest day in Yazd (16th of August), the maximum difference between outside temperature and inside in 5 am, temperature in



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HOURLY TEMPERATURES – Hottest Day
( 16th August)
Zone:  No. 1
|HOUR  | INSIDE | OUTSIDE | TEMP.DIF |
|      |  (C) |   (C) |    (C) |
+------+--------+---------+----------+
|00   |  33.7 |  30.6 |    3.1 |
|01   |  33.5 |  28.3 |    5.2 |
|02   |  33.0 |  26.3 |    6.7 |
|03   |  32.5 |  25.0 |    7.5 |
|04   |  32.2 |  22.8 |    9.4 |
|05   |  31.9 |  22.3 |    9.6 |
|06   |  32.2 |  23.1 |    9.1 |
|07   |  32.8 |  27.5 |    5.3 |
|08   |  33.7 |  31.1 |    2.6 |
|09   |  34.3 |  34.3 |    0.0 |
|10   |  34.8 |  36.7 |   -1.9 |
|11   |  35.0 |  38.7 |   -3.7 |
|12   |  34.9 |  40.3 |   -5.4 |
|13   |  35.1 |  41.6 |   -6.5 |
|14   |  35.3 |  42.2 |   -6.9 |
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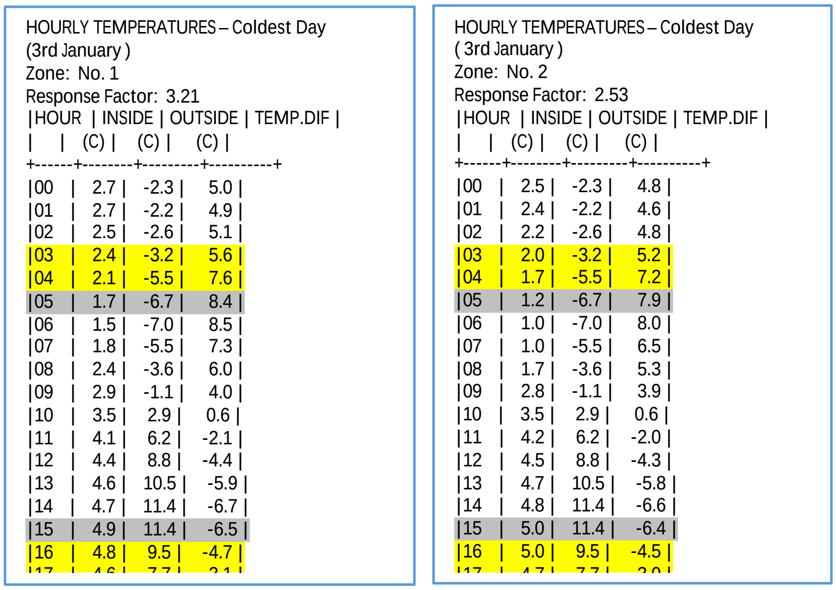
HOURLY TEMPERATURES – Hottest Day
( 16th August)
Zone:  No. 2
|HOUR  | INSIDE | OUTSIDE | TEMP.DIF |
|      |  (C) |   (C) |    (C) |
+------+--------+---------+----------+
|00   |  33.6 |  30.6 |    3.0 |
|01   |  33.3 |  28.3 |    5.0 |
|02   |  32.7 |  26.3 |    6.4 |
|03   |  32.2 |  25.0 |    7.2 |
|04   |  31.7 |  22.8 |    8.9 |
|05   |  31.3 |  22.3 |    9.0 |
|06   |  31.5 |  23.1 |    8.4 |
|07   |  32.3 |  27.5 |    4.8 |
|08   |  33.6 |  31.1 |    2.5 |
|09   |  34.5 |  34.3 |    0.2 |
|10   |  35.0 |  36.7 |   -1.7 |
|11   |  35.1 |  38.7 |   -3.6 |
|12   |  35.0 |  40.3 |   -5.3 |
|13   |  35.3 |  41.6 |   -6.3 |
|14   |  35.5 |  42.2 |   -6.7 |
```

Fig. 1: Hourly temperature profiles for hottest day in Yazd (August 16th): the coldest and hottest hours are highlighted. In Zone No. 1, the differentitation in Max. and Min. temperatures are greater. Also, overall dif ferentiation of inside and outside temperature is higher in Zone No. 1



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HOURLY TEMPERATURES – Coldest Day
(3rd January )
Zone:  No. 1
Response Factor:  3.21
|HOUR  | INSIDE | OUTSIDE | TEMP.DIF |
|      |  (C) |   (C) |    (C) |
+------+--------+---------+----------+
|00   |   2.7 |  -2.3 |    5.0 |
|01   |   2.7 |  -2.2 |    4.9 |
|02   |   2.5 |  -2.6 |    5.1 |
|03   |   2.4 |  -3.2 |    5.6 |
|04   |   2.1 |  -5.5 |    7.6 |
|05   |   1.7 |  -6.7 |    8.4 |
|06   |   1.5 |  -7.0 |    8.5 |
|07   |   1.8 |  -5.5 |    7.3 |
|08   |   2.4 |  -3.6 |    6.0 |
|09   |   2.9 |  -1.1 |    4.0 |
|10   |   3.5 |   2.9 |    0.6 |
|11   |   4.1 |   6.2 |   -2.1 |
|12   |   4.4 |   8.8 |   -4.4 |
|13   |   4.6 |  10.5 |   -5.9 |
|14   |   4.7 |  11.4 |   -6.7 |
|15   |   4.9 |  11.4 |   -6.5 |
|16   |   4.8 |   9.5 |   -4.7 |
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HOURLY TEMPERATURES – Coldest Day
( 3rd January )
Zone:  No. 2
Response Factor:  2.53
|HOUR  | INSIDE | OUTSIDE | TEMP.DIF |
|      |  (C) |   (C) |    (C) |
+------+--------+---------+----------+
|00   |   2.5 |  -2.3 |    4.8 |
|01   |   2.4 |  -2.2 |    4.6 |
|02   |   2.2 |  -2.6 |    4.8 |
|03   |   2.0 |  -3.2 |    5.2 |
|04   |   1.7 |  -5.5 |    7.2 |
|05   |   1.2 |  -6.7 |    7.9 |
|06   |   1.0 |  -7.0 |    8.0 |
|07   |   1.0 |  -5.5 |    6.5 |
|08   |   1.7 |  -3.6 |    5.3 |
|09   |   2.8 |  -1.1 |    3.9 |
|10   |   3.5 |   2.9 |    0.6 |
|11   |   4.2 |   6.2 |   -2.0 |
|12   |   4.5 |   8.8 |   -4.3 |
|13   |   4.7 |  10.5 |   -5.8 |
|14   |   4.8 |  11.4 |   -6.6 |
|15   |   5.0 |  11.4 |   -6.4 |
|16   |   5.0 |   9.5 |   -4.5 |
```

Fig. 2: Hourly temperature profiles for coldest day in Yazd (3rd January): the coldest and hottest hours are highlighted. In Zone No. 1, the differentiation in max. And min temperatures are greater. Also overall differentiation of inside and outside temperature is higher in Zone No. 1

Zone No. 1 is 9.6°C but in Zone No. 2 is 9°C. Also in hottest time of this day which is more important, the maximum difference of outside and inside temperature is -6.8°C for Zone No. 1 and is -6.5°C for Zone No. 2 (Fig. 1).

Also in comparison between tables of hourly temperature profile for coldest day in Yazd (which is 3rd January), it can be seen that again, difference between outside and inside temperature in maximum and minimum temperatures of the day in Zone No. 1 is higher than Zone No.2 which can be one of criterions that indicate better response of Zone No.1 for temperature changes and thermal balance. Response factor dedicated to Zone No. 1 in 3.21 and for Zone No. 2 is 2.53. Although, this factor is a conclusion and overall of so much of interrelated data and results but again, it can be concluded that Zone No. 1 has a better thermal response rather than Zone No. 2 (Fig. 2).

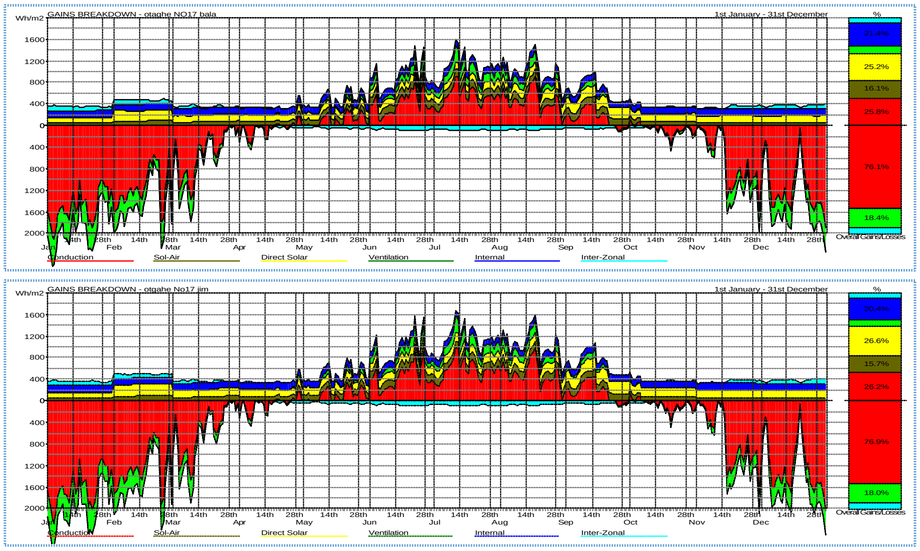


Fig. 3: Total heat gains and loses breakdown analysis: total heat and energy gain and loses of Zone No. 1 and 2 that in Zone No. 1 in both occasions, percentage of energy gain and lose from conduction is less than Zone No. 2. This can help to have less fluctuations of temperature in interior spaces

Passive heat gain lose breakdown analysis: These figures show total energy gain and loses in all months of year from different types of energy or heat gain and loses through overlaying all of them in this figure and differentiating them by colours. As said, these figures can show gains (the upper part of figure) and also loses (downside of figure) of energy from different sources. In negative part of both figure it can be seen that more than three quarter of energy and heat loses, occurs with conduction and we know that most part of this energy conducted by wall's and windows' surfaces. If we compare both figures of Zone No. 1 and 2, we can see that total energy and heat loses in Zone No. 2 is more than Zone No. 1. Supposedly, that is more correspondent with more total surface area of Zone No. 1.

Again, with comparing upper part of the figures, we can see Zone No. 1 gain less heat and energy from conduction in summer days that make this rooms (or zones) more convenient to live. In overall, because of less volume/area (which ratio factor again is related with total surface area/area) and more total surface area to ground area ratio, the mass and "fabric" that can absorb heat and then radiate it back to the space, get more, so the process of cooling and heating of space by cooling and heating of outside temperature get more slowly and fluctuations of interior temperature get very less as it can be seen in total heat and energy gain and loses of Zone No. 1 and 2 that in Zone No. 1 in both occasions, percentage of energy gain and lose from conduction which effect much of energy transitions in zones is less than Zone No. 2 (Fig. 3).

Monthly degree days: These series of results which consist of tables and figures, came out of very multi-layered input data and interpreting them singularly and without consideration of other results is very hard. For extracting this information has been said, input data is so much and accuracy of them have a significant effect on results. For this reason, here is input data for software simulation that given t-o the software.

The 18-26°C defined as human comfort range, activity rate been adjusted to mid. Activity (70 W), air change rate is 0.25, wind sensitivity is 0.25 (air change/hour), clothing defined to light home clothes (t-shirt and trousers), humidity 60% and air speed defined to 0.5 m sec^{-1} (pleasant breeze). Also, occupancy times of this space been defined to all days of week and for all 24 h of a day because the original function of this building was domestic.

In general, this analysis, show the accumulated hours for each month that spent out of human comfort band. Thus one interpretation for these outputs is the total hours that we must spend energy to create thermal balance in interior spaces. Therefore if we check the two tables that are for Zone No. 1 and 2 and compare the total degree hours of each month, we can understand which zone have a better passive conditions in interior space (Fig. 4).

As it can be seen in Fig. 5 total energy loses (that must be compensated by external energy devises or sources) in Zone No. 1 is up to 10% less than Zone No. 2. Also in summer months, total gains that make that zone warmer than what human comfort need in Zone No. 2 is

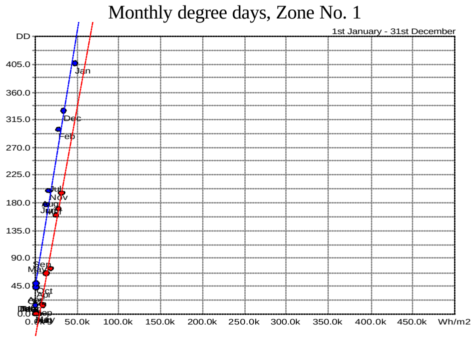
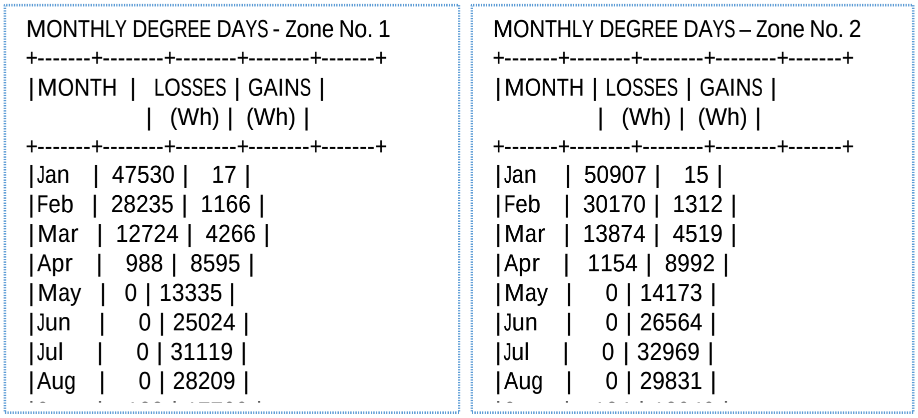


Fig. 4: Monthly degree days of Zone No. 1 and 2: this figures show total monthly degree days (in vertical columns) and total energy required for balancing interior thermal condition correspondent with human comfort (in horizontal rows)



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MONTHLY DEGREE DAYS - Zone No. 1
+-------+--------+--------+--------+-------+
|MONTH  |  LOSSES | GAINS |
        |  (Wh) |  (Wh) |
+-------+--------+--------+--------+-------+
|Jan   | 47530 |   17 |
|Feb   | 28235 |  1166 |
|Mar   | 12724 |  4266 |
|Apr   |   988 |  8595 |
|May   |    0 | 13335 |
|Jun   |     0 | 25024 |
|Jul   |     0 | 31119 |
|Aug   |     0 | 28209 |
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```
MONTHLY DEGREE DAYS – Zone No. 2
+-------+--------+--------+--------+-------+
|MONTH | LOSSES | GAINS |
        |  (Wh) |  (Wh) |
+-------+--------+--------+--------+-------+
|Jan    | 50907 |   15 |
|Feb    | 30170 |  1312 |
|Mar    | 13874 |  4519 |
|Apr    |  1154 |  8992 |
|May    |     0 | 14173 |
|Jun    |     0 | 26564 |
|Jul    |    0 | 32969 |
|Aug    |     0 | 29831 |
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Fig. 5: Monthly degree days for Zone No. 1 and 2: to getting a thermal balance correspondent with “human comfort” range in 1 year period, we need 10 KWH (Kilo Watt Hour) more energy to heating more Zone No. 2 and about 9 KWH more energy to cooling down this room in hot days

again about 9% more than Zone No. 1. Thus, these analysis shows that to getting a thermal balance correspondent with “human comfort” range in 1 year period, we need 10 KWH (Kilo Watt Hour) more energy to heating more Zone No. 2 and about 9 KWH more energy to cooling down this room in hot days (Fig. 5).

CONCLUSION

In thermal balance equation:

$$QS+QE+QI+QV+QF = 0$$

Where:

QS = Direct and indirect “solar” gains
QF = Amount of evaporative gains
QI = Internal gains
QV = Ventilation gains and finally
QF = Fabric gains which includes gains of energy from all mass and materials (Mostly by conductance an in some references, it is cited as Qc)

The heat flow through a sunlit opaque element will then be $Qc = A\times U\times(T\ s\text{-}a\text{-}Ti)$ the effect of air temperature is evaluated by the conduction expression (Qc) as using $Qc = \sum(A \times U)$ for the whole building and the extra heat flow caused by solar radiation will be calculated separately for each side. Thus in this equation, more surface area, means more gained and stored energy as “fabric gain”. But this research, investigate effect of V/A (volume to area) ratio on energy cycle of a space. Results show that with more V/A ratio, difference between minimum and maximum temperatures within a day or throughout the year get bigger, so interior space’s thermal conditions change more frequently which have a negative effect on human comfort. Therefore, for a better thermal conditions, V/A ratio must have a smaller amount.

Also, by keeping total exposed area to a specific exposure the same and by having the same area of windows or sources of penetrating sunlight with increasing ratio of interior or exterior TSA/A (Total Surface Area/Area) and TSA/V (Total Surface

Area/Volume), the general fluctuation of temperature in interior spaces, getting less frequent, within a day and also in a period of whole year. In addition, increasing TSA/V or TSA/A can help to decreasing total energy cycle and in such a hot dry climate of Yazd, it means less need for heating in winter and less cooling in summer. Tables and figures extracted from monthly degree days in case study of two relatively identical zones of Mortaz historical house, confirm this conclusion which show that in simulated zones, relatively close area ($A = 56\ m^2$) and volume ($V = 330\ m^3$) but with higher TSA/A and TSA/V ratios which V/A ratio of Zone No. 1 = 5.7 and V/A ratio of Zone No. 2 = 6 and TSA/A ratio of Zone No. 1 = 6.92 and TSA/A of Zone No. 2 = 5.83 have a better thermal response and in 1 year period, Zone No. 1 need around 19 KWh energy to compensating interior conditions to defined comfort criteria. This amount is approximately, 8% less than Zone No. 2.

Still there is needed more case studies or more comprehensive researches by live monitoring in experimentally provided spaces with accurate measurement devices or other research methods to get confirmed this findings. Also more software simulations in different climates or by changing V/A and/or TSA/V would help to ground more accurate conclusions in this field of study.

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