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Study of Thermal Conditions for Residents of Apartment Buildings on Northern and Southern Fronts

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ABSTRACT

Given that thermal conditions for resident of high buildings are different from those of conventional ones, it is inevitable and necessary to study such buildings in order to provide quiescence and to reduce energy consumption. The aim of this paper is to examine thermal conditions for 2 groups of residents of northward and southward high apartment buildings in Iran in order to determine their thermal Comfort limits. Method used by this research is to analyze field studies in addition to library ones, therefore, thermal (including temperature and humidity) recording devices were used for field studies. Results of this study, which is based of comparing to ANSI/ASHRAE standard 55, indicate that , on the average, residents of southward units enjoyed maximal level of thermal comfort during summer peak hotness while residents of northward units enjoyed less thermal comfort level. As a result, energy consumption is higher in northern front than that in southern one. So a step can be taken toward reducing energy consumption in residential sector by identifying energy – effective varieties.

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INTRODUCTION

Century 21 is the century of cities, when move than a half of the world population is residing in urban environments. In 2000, population of the world's cities was 6.1 billion people accounting 47% of total population of the world, which is estimated to increase and reach 60% of 8.1 billion people in 2030. So, the more the increase in the urban population, the higher the increase in the energy consumption. Following an increase in the price of petroleum in 1973, on the other hand, developed industrial countries had to take the issue of energy more seriously. Depending on the rate of industrial activities, 30-35% of total consumed energy is related to construction applications in different countries. On the other hand, it needs to be taken in to account that a vast volume of research done during the last century in the field of thermal comfort in order to design and keep thermal environments comfort is reflected in international standards (de Dear, 2004). During this period of time, 2 major approaches to the research into thermal comfort existed, namely.

1. Lab-based approach like Fanger's PMV-PPD model (1970), and
2. Approach based on the field studies such as compatible comfort standard. Both approaches have been outlined in the latest edition of ANSI/ASHRAE standard 55 (conditions of thermal environments for human settlements) (ASHRAE, 2004).

Investigations in the field of compatible thermal comfort models indicate that such models specify broader temperature ranges in which residents of building may gain thermal comfort.

In order to support finings of this study, its researchers believe that it is important to perform subjective studies in order to take real thermal feelings of these buildings residents into account. However, due to such limitations as differing age and sex groups, it was too difficult to perform formal subjective studies, especially in the form of questionnaire , on residential apartment buildings.

Thermal comfort conditions were investigated by a combination of monitoring parameters influencing resident's thermal comfort and observing residents and environments. Findings of monitoring were compared to thermal comfort-related international standards including ASHRAE, ISO, and CIBES.

Of applied standards, CIBSE (CIBSE, 1999) and Iranian standard (MPO, 2004) specify ranges of internal temperature and relative humidity to achieve thermal comfort. International standards ISO 7730 (ISO 2005) and the latest edition of ASHRAE standard 55 (ASHRAE, 2004) specify a range to predict either average opinions of residents (PMV) or their dissatisfaction (PPD) in order to achieve thermal comfort on the basis of 6 PMV or

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PPD defining factors (Olesen & Parsons, 2002). Table 1 gives respective thermal comfort ranges cited from standards.

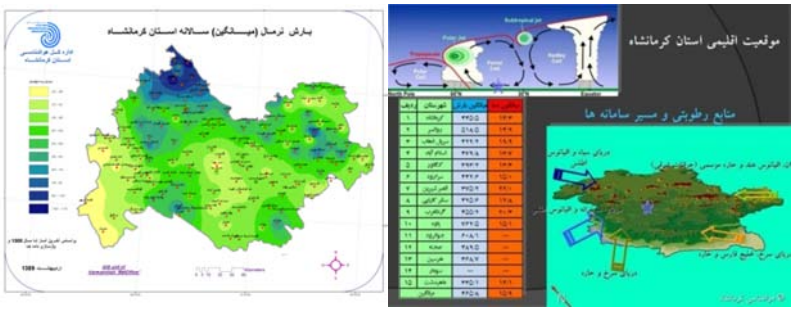
Table 1: Recommended conditions for providing thermal comfort in different standards.

Standard	Recommended thermal condition to achieve thermal comfort
ASHRAE	-0.5<PMV<+0.5, PPD<10% and 0<humidity ratio<0.012
ISO 7730	-0.5<PMV<+0.5, PPD<10% and 30%<RH<60
CIBSE	22 ºC <Temp<24 ºC and 30%<Rh<60
Iranian Regulation	20 ºC <Temp<23 ºC (winter) , 24 ºC <Temp<28 ºC (summer) and 30%<Rh<60

1. Geographic conditions of Kermanshah:

As selected area for filed study, Kermanshah is located in cold and mountainous region of Iran.

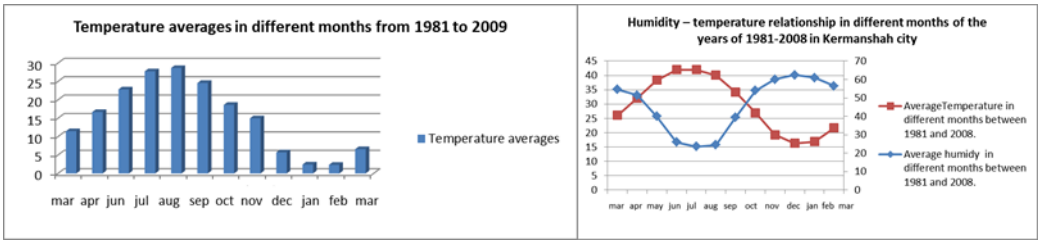
With elevation of 1420 m from average level of high seas. This city is situated in the west of Iran at North latitude and East longitude relative to Greenwich meridian, which exhibits highly variable climate (IR, 2007).



(1) (2)

2- Research method for formulating measurements of thermal comfort:

All reference standards require measurement of relative humidity and air temperature in order to evaluate thermal comfort. For calculations contained in ISO 7730 and ASHRE standard 55, it is necessary to observe status of clothing and activity and to estimate radiative temperature as well as speed of air current (Parsons, 2003). In this study, building monitoring along with observations and examinations of residents and sites were applied as data gathering methods.



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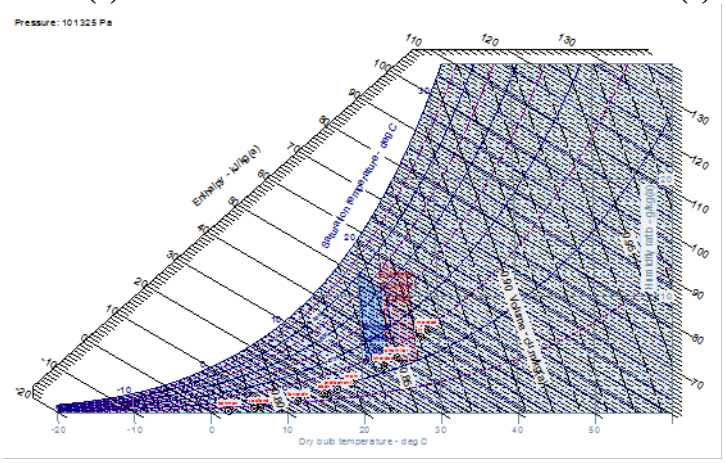

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2.1. Descriptions of studied cases:

In order to examine the status of thermal conditions in residential apartment units in the city of Kermenshah, we decided to study conditions of temperature, humidity, etc in these units during summer period of time from 07.25.2010 to 08.01.2010.

Therefore, 2 apartment units on northward and southward fronts with an approximate area of were considered. Initial questions asked from residents showed livening rooms accounted for the maximum space used by them round – the – clock, therefore, living rooms with an approximate area of on northward and southward fronts were selected as study cases and monitoring physical parameters was carried out in 2 living rooms during summer. For the study purposes, we tried to consider identical living rooms, each in one unit, in terms of total area of residential units, area of living room, the height to ceiling from the floor, area of detach able into living rooms, year of building construction, etc.

Under – study buildings have water cooler for summer cooling. It was possible residents to control thermal conditions by opening – closing windows in order to use natural ventilation in addition to mechanical systems.

2.2. Data gathering:

Temperature was recorded by spherical thermometers, which record a mean of radiative temperatures and air ones, in order for calculations of average radiative temperature to be possible. Data on heat and relative humidity was calibrated using loggers and recorded as summer records every 15 min during a week for each study case. Three kinds of thermal probe named Tiny tag ultra, Tiny tag plus, and Tiny talk were used, as recorders of thermal and relative humidity data, to perform short term measurement, of course, all of which were calibrated and guaranteed in terms of their precise efficiency before being used.

External conditions of buildings were monitored in addition to the measurements of thermal conditions inside buildings. All measuring instruments used internally were placed near to resident's resting place in order for measured conditions to reflect conditions in which residents live. Of course, these instruments were kept in the rooms out of the reach of children and other user in order to record data while minimizing errors of recording. Location of devices was set away from direct impacts of energy sources such as exit shutters of cooling system, sunlight, equipment, etc. Figure 2 depicts tools used for monitoring.

Visiting selected units made observation of residents wearing clothes and activities manners as well as air circulation in the space possible. Having measured randomly the air speed within monitored rooms, we observed no considerable air current on cases studied; therefore, we set this variable at the value of in order to cover air speed for all monitored rooms.

Fig. 2: Measuring tools used for monitoring.

During the period of study and summer time, residents exhibited no different levels of clotting and activity, but rather they used some clothes specific to that season. Based on observations of residential units, it was known that they used comfort, loose fitting, and often short-sleeved clothing while having strange guests and or for religious reasons they wore veiled clothes merely. In fact, residents were free to wear different clothes and to change them during study period. Cultural, occupational, and gender protocols were identified as important parameters influencing veil level within units.

Each unit residents' veil, clothing, and activities as well as the speed of air flow taken into account by calculations in order to determine the level of thermal insulation. It is very difficult to determine levels of clothing insulation that cover all residents considering different types and genders of residents including children and adults. Therefore, present research considered 3 averages of clothes levels observed for women, men, and children with respect to 3 main groups of people living in such spaces. This study assumed that combinations of clothing types create average thermal insulation of .34, 1.2, and .88 clo (Fazeli N, 2007)for men, women, and children, respectively. Present study also assumed a range of thermal insulation of clothes between .5 and 1.2 clo for women given the possibility of changing veil. Also, to determine the levels of residents' activities is complicated due to various amounts of activity. Residents exhibit different rates of body metabolism in such different situation as sleeping, leaning back, resting, and walking.

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2.3. Analyses and results:

This research presents real thermal conditions found based on measurements and monitoring,

2.4. Thermal condition required by residential apartment buildings in Iran (Theoretical considerations):

According to table 1, CIBSE standards (CIBSE, 1999) have specified only the ranges of temperature and relative humidity to achieve thermal comfort although we know that different groups (women, men, children, the elderly) residing in residential units have differing needs for temperature and relative humidity to achieve thermal comfort. Such differences are due to differences in the levels of activity and clothing specific to any different age and gender groups often benefiting from thin and unclosed clothes in order to order to achieve maximum thermal comfort during summers. This table gives feasible temperature ranges required by various types of residents. So it can be observed that there exist no simply attainable overlap of temperature ranges meeting demands of both men and women – when with a relative humidity about 40% , the speed of air flow is fluctuating in a range between .1 and 5 ms .

As expected, this study shows that higher speed of air flow in the rooms extends upper limit of acceptable temperature range with which residents feel comfortable (with relatively higher temperatures than usual, residents still feel comfortable thermally) although there seems to be no proper combination of the room temperature and speed of air flow meeting thermal comfort needs of both male and female residents.

2.5. Results obtained from experimental studies:

Results from experimental and field studies. Indicate that for recommended ranges of temperature and relative humidity, in general, monitored southward unit living room was in accordance with Iranian standard within 10% of time, wich is 5% for Northward unit. In southward unit, cooling degree in much more higher and the number of hours when water cooler is on at minimum rate is much less than those in northward unit due to the proximity of cooler to the living room. In northward unit, cooling degree has decreased sharply and water cooler is on with maximum rate round the clock, cooling and moisturizing space, due to more use of south light in the building during summer hot days, to the lack of appropriate horizontal and vertical shades in the building, and to the location of water cooler on the roof o the building(Ghahtemani A., 2008).

Recorded values of humidity and heat well indicate builders' carelessness, not paying attention to the climate while placing cooling equipment at an improper site, 2 tasks which must be paid attention to seriously given the high price and insufficiency of fossil fuels, table 2 summarizes findings on time percentages when 2 north – and southward units reached values recommended by standards.

Table 2: Summary of findings from examination of buildings studied (northward and southward units.

		Northward 4th Floor	South ward 4th Floor
1	Unit area	95 m^2	95 m^2
2	Unit height from the ground surface	16m	12m
3	Whether windows are shaded vertically?	No	No
4	Whether windows are shaded horizontally?	No	No
5	Is connected to controlled space of underneath floor?	Yes	No
6	Internal temperature mean for 1 week	27.7 °C	28.89 °C
7	Internal humidity mean for 1 week	42.56%	39%
8	Residents' self-reported thermal comfort(too cold, cold, neutral warm, hot)	Warm	Warm
9	Standard-based residents' comfort percentages (temp: 23 -26 °C; RH: 30%-60%	5%	10%

Figures 3-1 to 3-3 show distribution of internal thermal conditions graphically for all buildings. They show that majority of measured data do not fall within limits recommended by Iranian regulations and CIBSE standards. As shown in figures, of course, wherever thermal data was out of acceptable ranges, rooms were perceived too hot and dry generally and residents of both north- and southward units lived under improper thermal conditions during summers, providing their comfortable conditions only by using cooling devices in different hours of days and nights, requiring a lot of power and water energy to consume.

Figures 3. Distribution of thermal conditions in the city of Kermanshah and internal spaces of 2 buildings studied.

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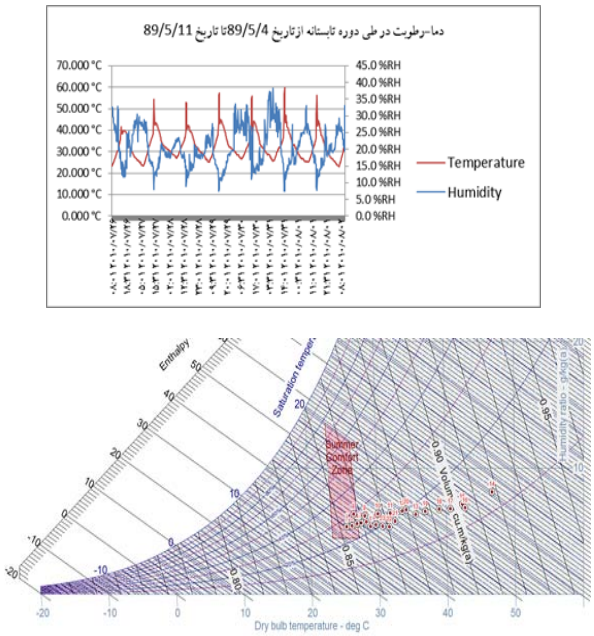

Fig. 3-1: Kermanshah city external temperature state and thermal comfort level.

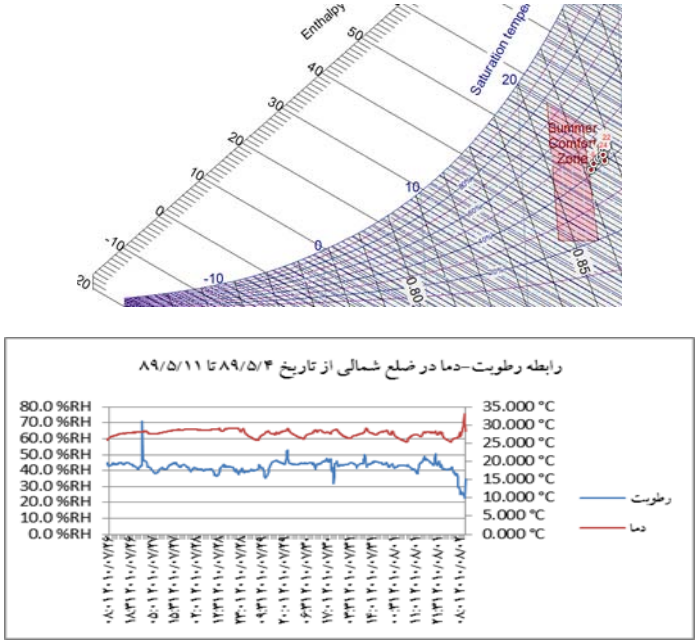

Fig. 3-2: Status of 4th floor northward unit and its residents' thermal comfort levels.

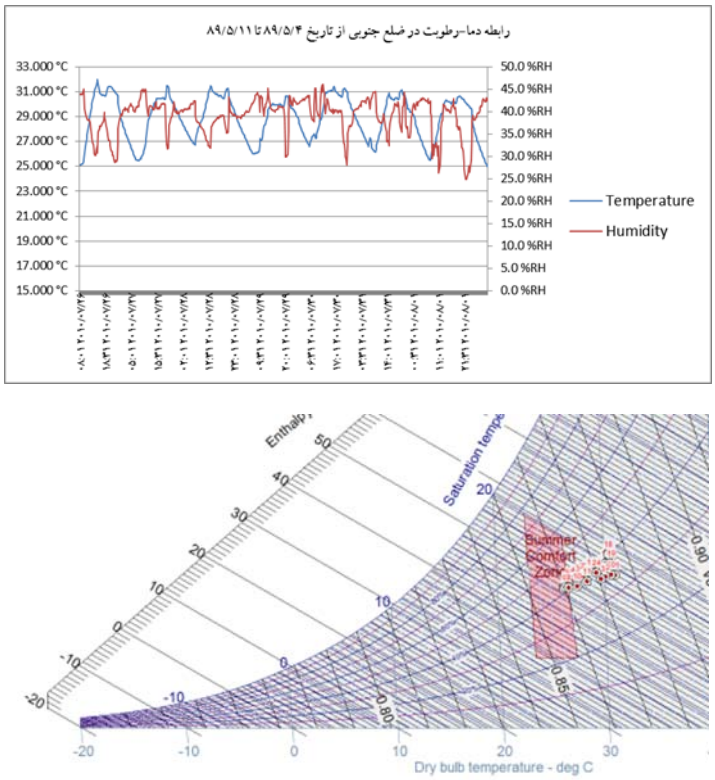

Fig. 3-3: Status of 4th floor southward unit and its residents' thermal comfort levels.

3.Conclusions:

On the basis of recordings done, it was found that residents of north- and southward units fall out of comfortable thermal limits, with northward unit residents being more dissatisfied and consuming more energy compared to those of southward unit.

According to what found by studying samples and comparing them with standards, although different groups (women, men, children) of residential units' user had different thermal needs being difficult to meet collectively and simultaneously, thermal conditions monitored inside residential buildings in Iran did not fall relatively in ranges recommended by National Building Regulations, Topic 19, Iran, and generally were out of thermal ranges recommended by international ISO, ASHRAE, and CIBSE standards. The most important result inferred from diagrams is the effect of low humidity in removing buildings from comfort limits. From psychometric table, it can be understood that for none of samples, cooling systems were not sufficiently capable of cooling environments, the efficiency of which had decreased sharply due to the location of water cooler on the building roof minimizing residents' thermal satisfaction, which ultimately led to increased power consumption because of increased hours of cooling devices working. Therefore, it is necessary to reconsider location of water coolers on the buildings' roofs and / or to exploit other systems for cooling the buildings that can reduce energy consumption while increasing internal humidity of buildings. For studied samples, on the other hand, it was found that builders' carelessness to climatic problems and insulation details, and application for not suitable windows caused apartment buildings to have humidity and temperature outside limits of comfort. In fact, whole energy standards are neither considered nor implemented perfectly for buildings and consequently, high apartment buildings act as a furnace in summertime so that they are able to provide thermal comfort for their residents merely by using mechanical devices and therefore, a huge amount of fossil resources is sacrificed through builders' , designers' , and administrators' carelessness while performing construction job.

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