Journal of Polytechnic, 2017; 20 (2) : 357-367

Investigation on the Effects of Thermal Parameters in Historic Primary School in İzmit in the Context of Refurbishment Process

Neslihan TÜRKMENOĞLU BAYRAKTAR*, Emre KİSHALI, Mohammad ABUDSAMHADANA
Kocaeli University, Faculty of Design and Architecture, Department of Architecture
(Received : 17.05.2016 ; Accepted : 21.09.2016)

ABSTRACT

Historic schools are the building types where climatic comfort requirements of students, influencing the learning process have to be maintained. These buildings face deteriorations in long periods by especially climatic parameters, causing insufficient conditions for the students. The diagnostic process for historic school buildings is important in order to investigate the existing problems on the envelope and climatic comfort conditions before implementation of intervention strategies. The combined effect of climatic parameters, changing heat gain and losses, thermal sensation and energy efficiency have to be examined in order to lower the energy consumption, create comfortable climatic environment for students which directly influence their concentration and health in the classrooms. In this context the level of climatic conditions in different oriented classrooms are investigated by thermal measurements and concurrently conducted survey with questionnaires in historic Ulugazi Primary School in İzmit, Turkey. During the measurement process of climatic parameters, a survey was conducted among 40 students in two classrooms, located on North-northwest, (NNW) and South-southeast, (SSE) orientations. The findings on distribution of individual thermal satisfaction sensation of the students obtained by the questionnaires were compared to the graphics of distribution of temperature, air velocity, humidity measurement values.

Keywords*: Thermal Performance, Thermal Comfort, Historic School Building, Non-Destructive Tests.*

ÖZ

Tarihi okul yapıları, öğrencilerin öğrenim süreçlerini etkileyen iç ortam iklimsel konfor gereksinimlerinin optimum koşullarda sağlanmasının gerekli olduğu yapı tiplerindendir. Bu yapılar uzun süreçlerde öğrenciler için istenmeyen iç ortam fiziksel koşullarının oluşmasına da neden olan dış ve iç iklimsel parametrelerin yarattığı bozulmalarla yüzleşebilmektedir. Tarihi yapılarda müdahale stratejilerini uygulamadan önce yapı kabuğundaki bozulmaları ve iç ortam iklimsel konfor seviyelerini belirlemek üzere teşhis süreçleri yürütülmelidir. Enerji tüketimini azaltmak ve sınıflarda öğrencilerin konsantrasyon ve sağlıklarını direkt olarak etkileyen konforlu iç ortam koşullarını yaratmak için iklimsel parametrelerin bileşik etkisini, değişen ısı kayıp ve kazançlarını, ısıl konfor memnuniyet derecesi ve enerji verimliliğinin incelenmesi gerekmektedir. Bu bağlamda ısıl ölçümler ve eşzamanlı olarak yürütülen anket çalışması ile İzmit tarihi Ulugazi tam zamanlı ilköğretim okulunda farklı yönlerde konumlanan sınıflardaki iç ortam iklimsel koşulların yarattığı etkiler incelenmiştir. KKB ve GGD yönlerinde yer alan sınıflarda öğrenim gören 40 öğrenciye iklimsel parametrelerin ölçümü esnasında anket soruları yöneltilmiştir. Isıl koşullardan memnuniyet derecesi ve dağılımına yönelik veriler sıcaklık, iç hava hareketi hızı ve nem dağılımına yönelik verilerle karşılaştırılmıştır.

Anahtar Kelimeler: Isıl Performans, Isıl Konfor, Tarihi Okul Binası, Hasarsız Test Yöntemleri.

1. INTRODUCTION

Historic primary schools are the building types which have to be cared not only for their historical values but also with the function of education which can only be satisfactorily provided when healthy and comfortable interior environment conditions in the classrooms are maintained. In these buildings, the students, at the age of 6-10 have to spend most of their daytime for education activities.

It has to be the first step to diagnose the behaviors and the effects of climatic parameters as humidity, temperature, interior air flow velocity in the classrooms which have direct effect on generation of optimum climatic comfort requirements of the students before the implementation of energy refurbishment activities. Micro climatic conditions, under the impact of physical environmental conditions influence not only the student's mental and physical performance during their education period but also the amount of energy consumption of the buildings. In the literature, it is stated that the studies on investigating the effects of thermal environments in the classrooms on students have been started since 1950s [1, 2, 3]. In school buildings some parameters become more of an issue. Comfort condition is under the effect of;

Physical parameters of environment as;

- Interior and outdoor air, surface temperatures,
- Relative humidity,
- Local airflow velocity,
- Odour,
- Interior environment comprising biologic, chemical pollutants,

*Corresponding Author
e-mail: neslihanturkmenoglu@gmail.com
Digital Object Identifier (DOI) : 10.2339/2017.20.2 357-367

- Surface colour,
- Lighting,
- Acoustic level,

Physiological parameters of occupants as;

- Age,
- Gender,
- Activity type,
- Metabolism rate,
- Clothing level,
- Social conditions [4,5]

Energy performances of school buildings in Greece have been evaluated by the measurement and simulation activities by Dimoudi et. al. and night ventilation strategy as an appropriate solution is recommended in order to stabilize interior thermal conditions [6]. The study providing data on energy performance of school buildings remaining from Hellenism Hellenistic period have been conducted by surveys in 135 schools and results have been compared by the other studies in the literature and also data on thermal comfort and interior air quality have been presented. [7].

Hourly temperature measurements and survey study have been generated in the study conducted by Theodosiou et. al. in order to determine climatic conditions and their effects on occupants in different classrooms [3]. Infrared thermography was used in order to investigate the existing condition of building envelope.

It is possible to ensure conscious and sustainable preservation by non-destructive test methods with comprehensive measurement and recognition process based on the collection of information in order to observe the current physical condition of the buildings, in terms of building envelope, the indoor comfort conditions and determination of its effects on the occupants [8, 9]. In this context, historic Ulugazi Primary School building in İzmit, Türkiye, under the effect of temperate - humid climatic conditions is examined in terms of the variation of physical environmental parameters in NNW and SSE oriented classrooms and their effects on student's climatic comfort sensations. The school complex includes historical building, constructed in 1932 and other 2 additional buildings one of which is constructed in 1964 and the other in 1992 [10]. Micro climatic conditions and their effect on students are investigated by the measurement processes of airflow velocities, temperature and humidity values and their variations in different locations of classrooms by comparison of questionnaire results giving information on individual thermal sensation of students to local environmental conditions in the classroom. Systematically collected measurements on 11 November 2015 are presented by areal map graphs for the 2 classrooms. Thermal sensation variations obtained by questionnaire results are compared with the results of measurements in order to get essential and fundamental data for further refurbishment strategies.

2. DIAGNOSIS PROCESS FOR ENERGY REFURBISHMENT IN HISTORIC SCHOOL BUILDINGS

Existing school buildings generate the largest group by 30 % among all public building typologies. In school buildings 67 % of total energy is spent for heating [11, 12]. Lowering energy consumption in these structures for energy efficiency contribute the national economy and mitigate the negative effects on environment caused by the consumption of energy resources. Besides, refurbishment of existing school structures would enable students to continue their educational life in better spaces providing higher thermal, visual and acoustical comfort conditions. Also historic school buildings have a special importance among existing school building stock which have to be renovated with care like other historic buildings without interference the original form, structure and envelope. They have to be sustained to next generation as being part of a common sense of a district with social, cultural, technical reflections of a period of time. Historic school buildings continue serving for education of students with their original function. Because of this, they are the building types where visual, climatic comfort requirements of students which directly affect their learning process have to be maintained besides structural conservation. Historic buildings can be kept alive if they serve with their original or new functions with structural protection which can not only be provided by structural interventions but also by energy efficient retrofit processes with consideration of comfort parameters for users. Energy efficient refurbishment is important for improving both the thermal and visual comfort conditions and reducing energy demand and consumption in heritage buildings. This must be cared more in historic school buildings as they are the places for students that they have to spend most of their day time.

These building types face deteriorations in long periods of time due to unwanted effects of climatic parameters and by seismic actions. They have to be renovated in order to increase the efficiency of microclimate, structure and provide energy conservation. Interior climatic conditions also change by the effect of new formation of structures around the building. Most of the time, these effects make the climatic and visual comfort conditions insufficient for the students in the historic school buildings. The diagnostic process for these buildings is an important approach in order to find out the existing structural situation, problems on envelope and visual, acoustical, climatic comfort conditions, before taking decision on the implementation of intervention strategies [13]. Diagnosis and monitoring instruments are used in order to study historic buildings and to find out the best technological and constructive energy retrofit solutions, to support their commissioning, to assess the actual performances of buildings once retrofitted and to monitor such performance.

In order to diagnose problems on the envelope and determine visual, acoustical, climatic comfort problems

in the zones before taking decision on implementation of intervention strategies, the existing thermal and visual comfort conditions have to be examined by surveys directly learning the satisfaction levels occupants particularly by survey activities and the micro climatic conditions that they are under the effect of should be monitored and observed as a primary step before energy refurbishment activities [14].

It is possible to obtain realistic data on building envelope and the physical conditions of interior ambient by preliminary and comprehensive research on existing and historic buildings by slightly destructive and non-destructive tests. Non-destructive tests (NDT) take part as wide spread used method for also historic buildings which comprise testing and measuring technics with minimum intervention on buildings. The technics provide investigation of the structural and micro climatic problems affecting building, occupants and assessment of the level and type of deteriorations on buildings [15, 16].

3. THE IMPORTANCE OF ANALYSIS OF INTERIOR THERMAL COMFORT CONDITIONS IN SCHOOL BUILDINGS

Thermal comfort is a feeling of satisfaction with the combination of climatic factors named as temperature, average radiant temperature, relative humidity, relative air velocity which occurs in interior environment. Thermal comfort is defined as *"that condition of mind which expresses satisfaction with the thermal environment"*, according to ASHRAE 2005 code (American Society of Heating, Refrigerating and Air-Conditioning Engineers) [17]. Indoor thermal comfort affects the health and the productivity of the occupants, especially the people who have to spend most of their time in interior spaces. Thermal sensation level which betray the feeling of how warm it is in an interior zone, changes according to everyone with different characteristics of physical, mental features as a matter of age, gender, habits, origin of location, activity and clothing level [18,19].

Also the most important parameters that effect thermal sensation are the parameters as temperature, humidity levels, interior air distribution and velocity, creating a combined effect on interior climate [20]. Primary schools are one of the most important building types in which healthy and comfortable interior environment conditions have to be maintained. Because climatic, visual, acoustical conditions of the classrooms affect the pros and cons of education period, through which the students have to participate by all their sensory perceptions. Minimal changes in room temperatures, in the appropriate limits of comfort schedules, influence the mental abilities which need full concentration as addition, subtraction, multiplication, and framing sentence in a positive or negative way. According to these studies, heating and climatization affect learning conditions. High temperatures in classrooms generate environment for diseases and also students face complications as breathing quickly, decrease in activity under the condition of even minimal increase in temperature and humidity. In these kind of environments, attention and abilities in implementation, listening and perception of students decrease. Comfort, activity and productivity increase in the classrooms which have low temperatures creating cooling effect. In these kind of interior environments students get more success on studies related to numerical and grammatical works. But it is specified that the manual skills and velocities of students decrease in low temperatures [3]. The effects of climatic parameters in inappropriate levels on human health can be seen in table1. ASHRAE 2005 Standard recommends acceptable operating temperature in winter comfort zones for clothing level of 0.9 clo as 21 – 24.5 ^{0}C for humidity range of, 30% and 20.5-23 ^{0}C, humidity range of 60 %.

Table 1. The effects of climatic parameters on human health in schools [5] (Çevresel parametlerın okullarda insan sağlığına etkisi)

Health problem	**Risk factor**
Eye, mouth, neural symptoms on throat	High temperature
	Poor natural ventilation
Nasal congestion, throatache and prunella	Low temperature
	Mechanical ventilation
	High temperature

4. INFORMATION ON CASE STUDY-HISTORIC ULUGAZİ PRIMARY SCHOOL

4.1 Definition of the Case Study

Original historic Ulugazi Primary School, built in 1932 after 9 years of the establishment of the Turkish republic, has the signs of modern architecture with its symbolic, historical, aesthetic characteristics of 1st National Architecture period (modern classic architecture) (Figure 1). It is located near a main road and walking route, ex-railway tracks transformed into pedestrian way, passing all along the city.

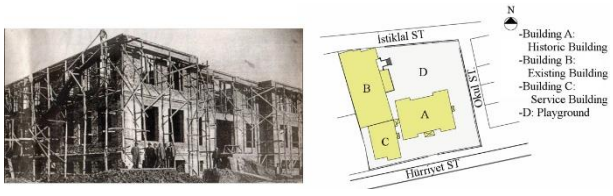

Figure 1. Historic Ulugazi Primary School in İzmit-Türkiye (Tarihi Ulugazi İlkokulu, İzmit – Türkiye)

Today it is comprised of 3 blocks constructed in different time periods. Education still goes on in the other blocks one of which was constructed in 1964 and the other in 1992 with original architecture features of historical

building [10]. Ulugazi Primary School complex has totally 22 classrooms in 3 blocks, 9 of which are located in historic building (A). Approximately 500 enrolled students aged between 6-11 are divided into two groups some of which to get education in the morning hours; 07:00 AM until 12:00 PM, while the second group to get education from 12:30 PM until 06:00 PM (Fig. 2).

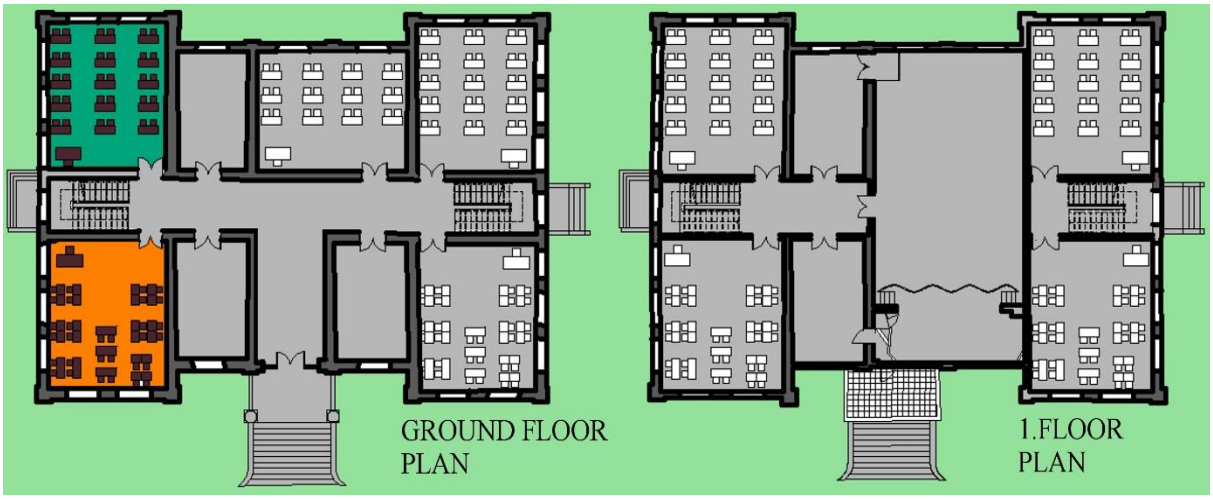

Figure 2. First and ground floor plan of the historic block of Ulugazi Primary School (Ulugazi İlkokulu tarihi blokun zemin ve birinci kat planları)

4.2 Definition of Climate in Kocaeli

Kocaeli is under the effect of temperate- humid climatic conditions. Coldest period actualize through the months as December, January, February and March. Average temperature obtained in these months is 7.4 ^{0}C. Lowest average temperature values as 3.4 ^{0}C are obtained in January and February. Measured lowest temperature value is -9.7 ^{0}C. Prevailing wind of coldest period acts from Southeast and West-northwest. Hottest period actualize through the months as June, July, August and September. Average temperature obtained in these months is 22.3 ^{0}C. Highest average temperature values as 29.4 ^{0}C is obtained on July and August. Measured highest temperature value is 44 ^{0}C. Prevailing wind in hottest period acts from south-east. An average value of temperature varies between 13-15 ^{0}C in spring and autumn. The measurements for the study were conducted on 11 November 2015 through the hours 11:15- 12:15 in both classrooms located on SSE and NNW orientations of Historic Ulugazi Primary School. Outside temperature, humidity values obtained during the survey and measurement processes were respectively, 21.2 ^{0}C and % 61 [21].

4.3 Classrooms

The findings of the results presented in this study were collected from measurement and survey campaigns in order to understand thermal comfort sensation levels of students. The study was carried out in 2 classrooms on the ground floor of Ulugazi Primary school building. The location of radiators for heating also can be seen as blue dots on the Figure 3.

Figure 3. NNW and SSE Oriented classrooms on ground floor plan in the historic building (Tarihi yapıda KKB ve GGD yönüne bakan sınıflar ve Zemin kat planı)

Thermal measurements and survey were conducted during lecture time when also active heating system operated. Two classrooms located on SSE and NNW of the building was selected for the study in order to compare the orientation effects on the thermal comfort sensation. Characteristics of the classrooms selected for the survey and measurement processes are defined on Table 2.

Table 2. Characteristics of the classrooms selected for the survey and measurement processes. (Araştırma ve ölçüm için seçilen sınıfların özellikleri)

	Orientation	**Location**	**Total number of the students**	**Number of the girls**	**Number of the boys**	**Average clothing level of the students**	**Met values of the students**
Classroom1 (3.rd class-9 years old students)	NNW	Ground floor	20	9	11	0.47 clo girls 0.41 clo boys	1.2
Classroom2 (3 rd class-9 years old students	SSE	Ground floor	20	12	8	0.32 clo girls	1.2

Questionnaire surveys were conducted among nine-year-old 40 students in 2 classrooms at the same time with measurements. Metabolic rate and cloth insulation were estimated in accordance with ASHRAE 2005. Metabolic heat production of students was assumed to fall into the category of 'light activity while seated' (1.2 met, or 70 W/m2) [22]. Respondents were wanted to write what they were wearing during survey by means of clothing checklist included in the questionnaire. Total "clo" values were calculated for every student by summing up clo values of every piece of clothing. Then average clo values are obtained for the girls and the boys separately (Fig. 4).

Humidity Temperature datalogger device located outside the building on North (Fig. 5).

Figure 5. Measurement equipment - respectively from left to right: datalogger, anemometer. (Ölçüm aletleri - soldan sağa doğru sırasıyla: veri kaydedici ve anemometer.)

Figure 4. Typical uniform clothing worn by students in Ulugazi Primary school (Ulugazi İlkokul öğrenciler tarafından kullanılan uniformalar).

5. MEASUREMENT AND QUESTIONNAIRES

5.1 Measurements of Thermal Variables

Extech AN340 CMM/CFM Anemometer/ Psychrometer Datalogger was used to measure interior ambient temperature, humidity and air flow velocities in the NNW and SSE oriented classrooms during survey process. Outside temperature and humidity variations during the study was recorded by Extech RHT10 18 reference measurement points located near the desks in the classroom were arranged in order to get information on the variation of temperature, humidity and airflow velocities affecting students individually at the sitting position height of 100-110 cm, as it can be seen from Figure 6. Temperature, humidity, airflow velocity values were read manually in every 3 minutes time period in every point with defined reference point order in the 2 classrooms concurrently through 11:15 - 12:15.

'Window1' and the door were open during the measurement and survey process in SSE oriented classroom. Curtain on the south wall was closed. 'Window 1' and 'Window 5' were open; the door was closed in NNW oriented classroom. Temperature values are higher in SSE classroom as expected in comparison to NNW classroom because of direct solar radiation gain from windows. Temperature values obtained by measurements in NNW oriented classroom can be seen on the graphics. Average, maximum and minimum temperature values are respectively; 24,5 ^{0}C, 25,4 ^{0}C and 22,6 ^{0}C.

Average, maximum and minimum temperature values obtained by measurements in SSE classroom are respectively, 25,8 ^{0}C, 26,5 ^{0}C, 24,9 ^{0}C. ASHRAE 2005 Standard recommends acceptable operating temperature in winter comfort zones for clothing level of 0,9 clo as 20,5-23 ^{0}C for humidity range of 60 % and 20,7-23,9 ^{0}C for humidity range of 50 %. Measured relative humidity values in both classrooms change in a range of maximum 60,4 % and minimum 47,5 %. Temperature, airflow velocity and relative humidity values measured in 18 points can be observed in Figure 7 and Figure 8. Airflow velocity entering from 'Window 5' is 0,8 m/s, from 'Window 1' is 0,4 m/s in NNW classroom. Airflow velocity entering from 'Window 1' and the door is 0.00 m/s.

The location of measured high, low temperatures and relative humidity values can be seen on the figure 9. High temperature values, among 26,4-26,1 ^{0}C are obtained at measurement points 4, 5, 6, 7, 8, 9, 18 located among south wall and the center of the SSE oriented classroom. Although inlet and outlet airflow velocities are 0.00 m/s, low temperature values, among 24,9-25,5 ^{0}C are obtained at the measurement points among open door and 'Window 1'. Maximum relative humidity values of 62,6 %-55,5 % are measured at the points, 1, 2, 3, 4, 5, 15, 18, near the east wall without window. Low relative humidity values are obtained in the middle part of the classroom and near the open window.

Figure 6. Measurement points in NNW and SSE oriented classrooms. (KKB ve GGD yönüne bakan sınıflardaki ölçüm noktaları)

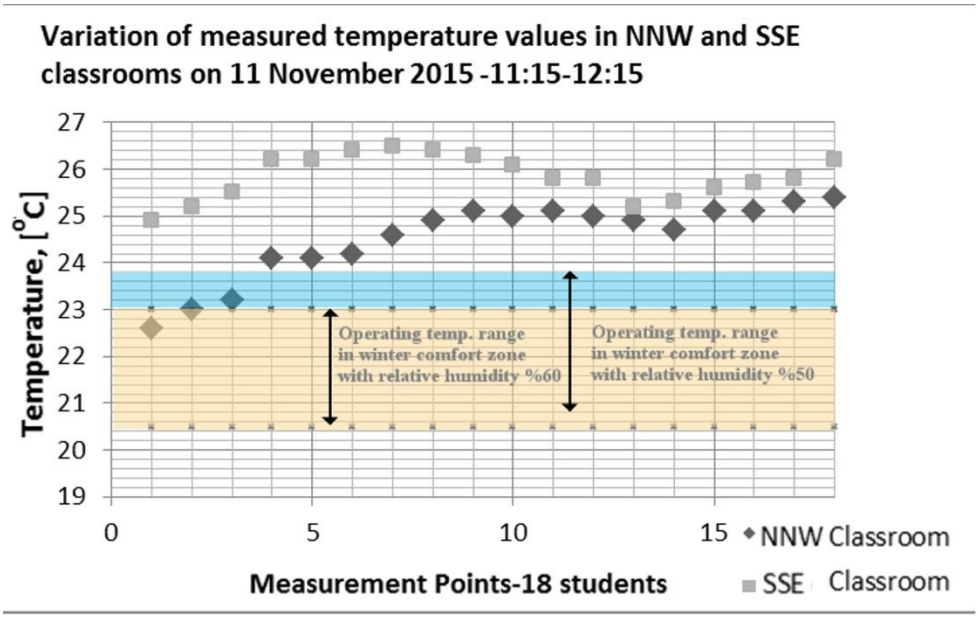

Figure 7. Temperature values in NNW and SSE classroom on 11.11.2015 through 11:15-12:15 (11 Kasım 2015 11:15 ve 12:15 arasında KKB ve GGD yönüne bakan sınıflardaki sıcaklık değerleri).

On the other hand, high temperature values, among 26,4-26,1 ^{0}C are obtained at measurement points 9, 10, 11, 12, 15, 16, 17, 18 in NNW oriented classroom. Although inlet and outlet airflow velocities are too low and lowest temperature values, 22,6- 23,2 ^{0}C are obtained at the measurement points near the door. Maximum relative humidity values are measured at the point '4' which is near the east wall without window. Lowest relative humidity values are obtained near 'Window 5' on the west wall.

categories: cold, cool, slightly cool, neutral, slightly warm, warm, and hot. The values -1, 0, +1 regarding slightly cool, neutral and slightly warm are accepted to be within the comfort zone. In the questionnaire students were asked about their personal information. There were questions on Fanger's seven point rating scales by which the thermal conditions of the classrooms could be evaluated [23].

Students' sensation of comfort was examined in two classrooms by questionnaire on 11 November 2015 in

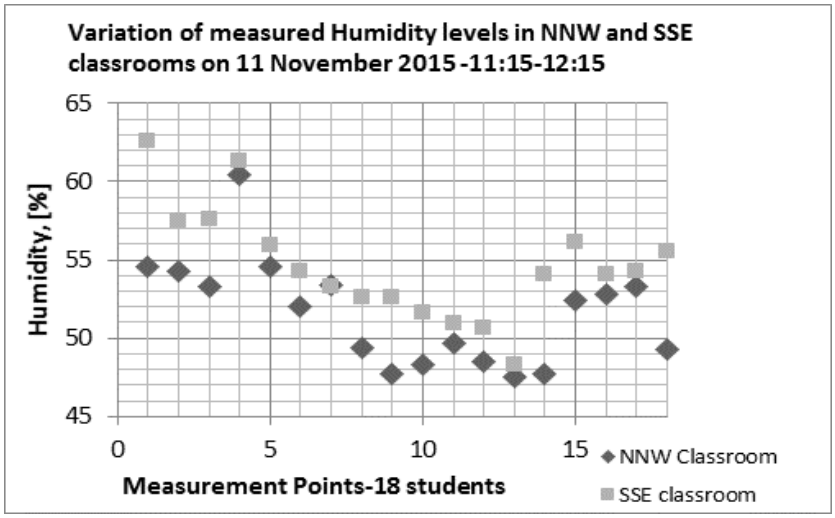

Figure 8. Relative Humidity values in NNW and SSE classroom on 11.11.2015 through 11:15-12:15 (11 Kasım 2015 11:15 ve 12:15 arasında KKB ve GGD yönüne bakan sınıflardaki bağıl nem değerleri).

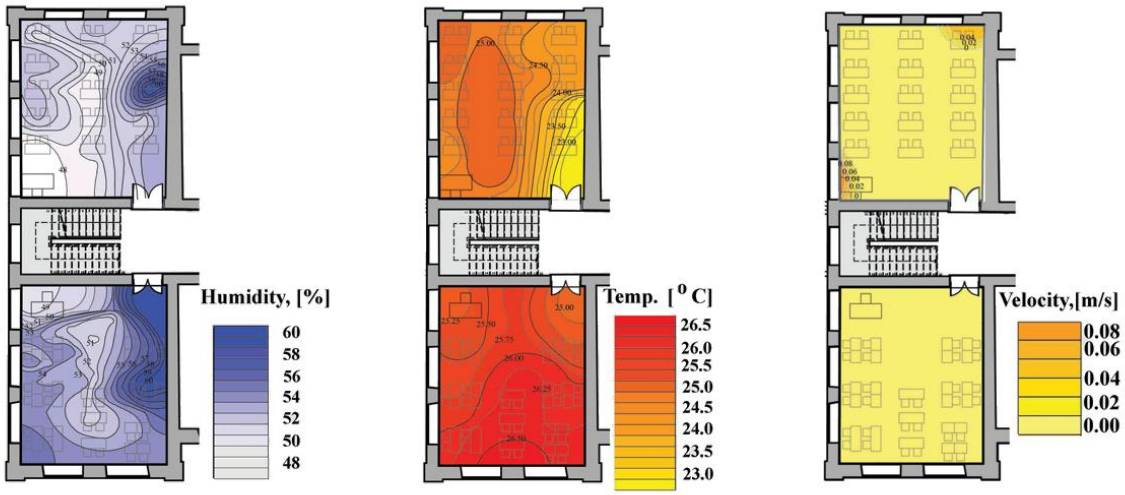

Figure 9. Relative Humidity values in NNW and SSE classroom on 11.11.2015 through 11:15-12:15 (11 Kasım 2015 11:15 ve 12:15 arasında KKB ve GGD yönüne bakan sınıflardaki bağıl nem değerleri).

5.2. Questionnaire

The subjective assessments were based on the occupants' vote on thermal sensation, thermal preference, thermal acceptance in terms of temperature, air velocity and humidity parameters in the occupied zone derived from ASHRAE 2005. Thermal sensation is defined with seven

historic block of Ulugazi Primary School. The questionnaire period was limited to one time in a day in order not to interrupt lectures. In the morning, through 11:15 – 12:30, questionnaires were answered by 3rd class students with average age of 9, in NNW and SSE oriented classrooms. The questionnaire derived from literature

was set up to understand the instantaneous sensation of students to microclimatic environment were delivered and answered by the students while measurements were enduring [19, 24, 25]. It included questions on; personal information (age and gender), thermal comfort questions including temperature, humidity and airflow velocity sensation level.

Students were wanted to mark on the clothing check-list what they wore during measurement and survey process. They also defined their location in the classroom. The criteria as temperature, humidity and natural ventilation sensation scale, satisfaction scale and preference scale were considered and asked to the students in the questionnaires as marking the appropriate level of sensation during survey and measurements. According to the results, 60 % of the students among 20 students with 9 girls and 11 boys stated that they were not satisfied with the thermal environment in the classroom, NNW (Fig.10). 40% stated that they felt comfortable while 55 % of the students expressed that the interior environments was hot and for some warm. While 45% wanted no change in temperature, 40 % preferred cooler environment in the classroom. 50% of the students stated that they were satisfied with humidity level while 35 % felt the sensation of dryness. 60 % of the students stated that still air conditions existed and 50 % wanted increase in airflow velocities in the classroom. 80% of the students wanted air conditioner in the classroom.

5.3. Comparison of Questionnaire and Measurement Results

Fanger's seven point rating scale was used to get information on the sensation of the students on natural ventilation potential, humidity levels and temperature [17]. It was stated by most of the students that the airflow velocity and distribution in the classroom was very poor although 2 openings in the opposite walls were open during the measurement process. Comparison of the votes of the students with the measured temperature and velocity range on the 18 reference points demonstrate the fact that all other students were unsatisfied in different levels by the airflow distribution and velocities in the NNW classroom except the students sitting close to the openings, 'Window 1- Window 5', under the effect of low volume flow rates. Highest measured temperatures were obtained close to west wall with a value of 25 ^{0}C but some of students sitting opposite east wall also voted as hot. Highest humidity levels in the classroom measured on these points can be the cause of this thermal sensation. It was stated by 50% of the students that the humidity level in the classroom was sufficient in classroom NNW. 35% of the students sitting near East wall stated that interior air was too dry although the measurement showed that the humidity level was the highest, close to these reference measurement points. Inconsistence in the sensation of the measurement results and students thermal sensation votes in terms of humidity

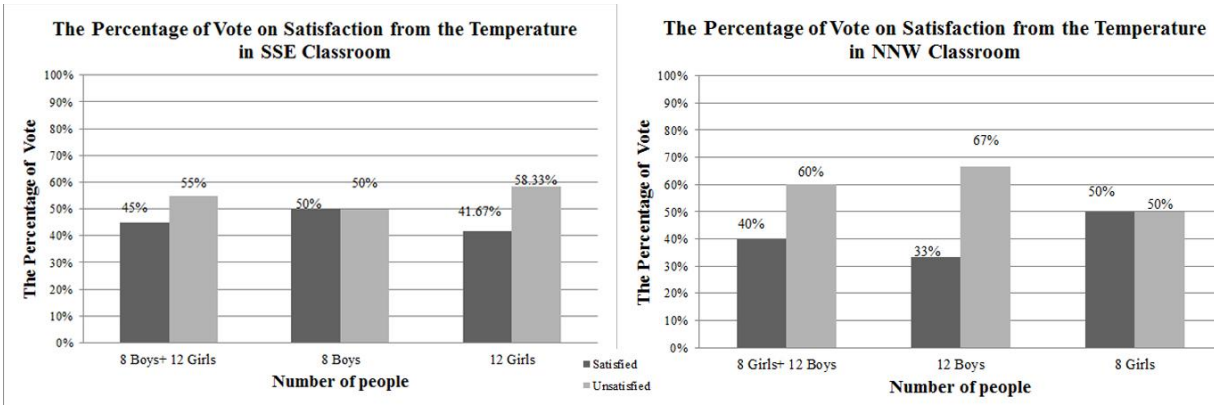

Figure 10. The percentage of satisfaction from the temperature in SSE and NNW classrooms (GGD ve KKB yönüne bakan sınıflardaki memnuniyet yüzdeleri).

According to the results, 55% of the students among 20 students with 12 girls and 8 boys stated that they were not satisfied with the thermal conditions in SSE oriented classroom **(**Fig.10). 20% stated that they felt comfortable while total 50% expressed that the interior environments was very hot and warm. While 30% wanted no change in temperature, 50% wanted the classroom to be cooler. 50% of the students stated that they were satisfied with humidity level while total 35% felt the sensation of humidity. %35 of the students stated that still air conditions existed. 50% wanted increase in airflow velocities in the classroom. 75% of the students wanted air conditioner in the classroom.

level, temperature can be because of the student's misunderstanding the questions on humidity. Temperature values in the classroom except reference measurement points, 1, 2, 3 are outside the comfort zone for mostly measured level of 60% and 50% relative humidity in NNW oriented classroom according to ASHRAE standard.

Although the door and 'Window 1' was open during measurement process in the classroom SSW, the answers of the students reveal the fact that most of the students found air flow velocities and distribution insufficient. Airflow velocities were measured as 0.00 m/s through the door and the window. This could be the blocking effect

of the other school construction very close to the historic school building to the wind acting on 'Window 1'. The windows on south wall also had closed curtains in order to get protection from solar radiation effects. Unfortunately the interior shading device as curtains inside the wall is insufficient way of protection from the unwanted effects of solar radiation as it cannot be blocked before it enters the classroom. This could be the cause of the results of the survey that showed, students sitting near the south wall with no open window felt the disadvantage of still air more in comparison to other students. In accordance with these results, temperature

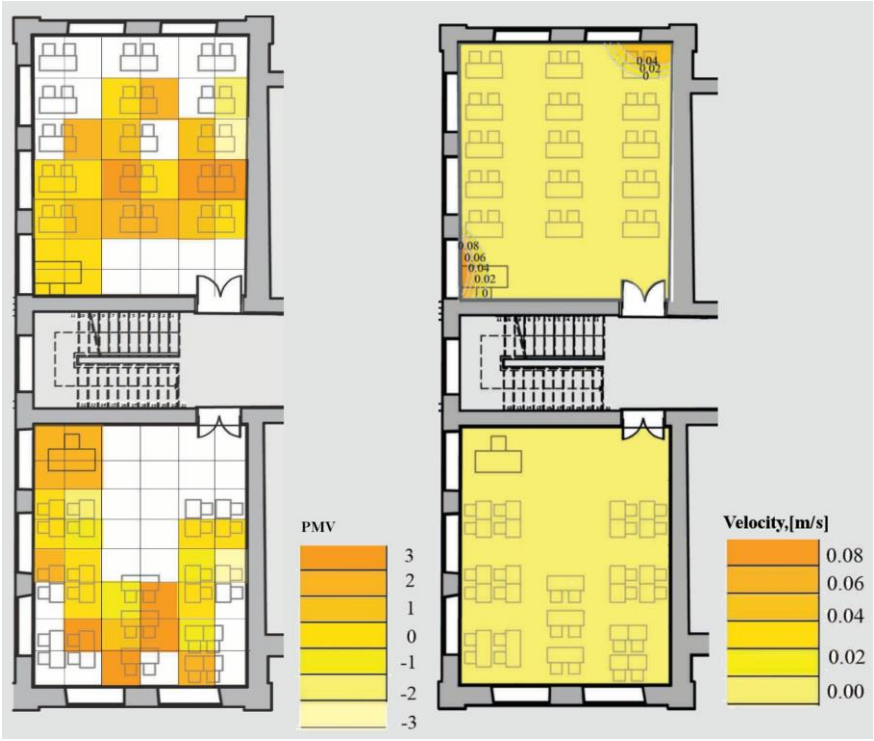

Figure 11. Comparison of air velocity results with questionnaire results of students in NNW and SSE classroom on 11.11.2015 through 11:15-12:15. (11 Kasım 2015 tarihinde 11:15 – 12:15 saat aralığında hava hareketi hız ölçümleri ve anket sonuçlarının karşılaştırılması)

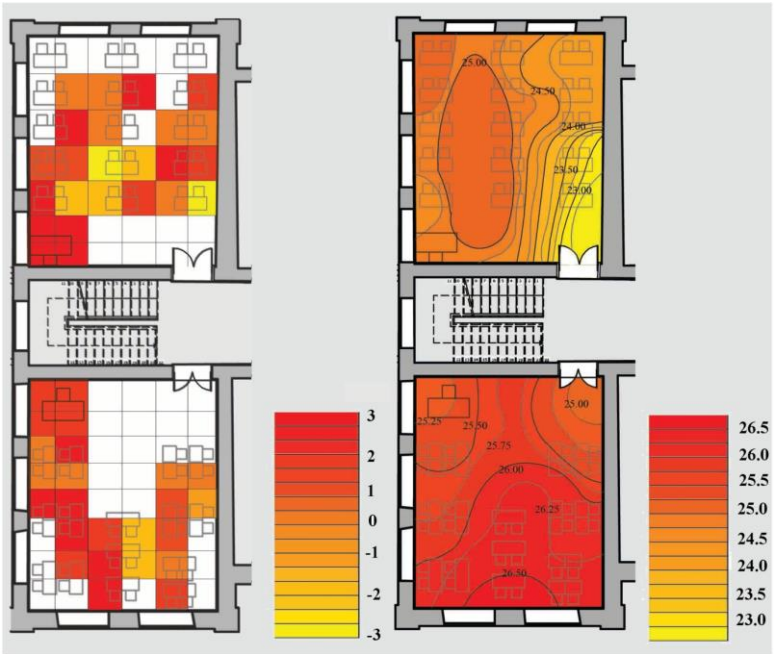

Figure 12. Comparison of temperature measurement results with questionnaire results of students in NNW and SSE classroom on 11.11.2015 through 11:15-12:15. (11 Kasım 2015 tarihinde 11:15 – 12:15 saat aralığında sıcaklık ölçümleri ve anket sonuçlarının karşılaştırılması)

values obtained near these part reach to high levels as it can be seen from the figure 13 and also students sitting near these measurement points stated that they felt very hot.

Half of the students in SSE classroom had satisfaction with humidity levels. 35% of the students sitting on the measurement points where the highest humidity values were obtained expressed that humidity level in the classroom was high as it was observed by the measurement process. All temperature values in the classroom are outside the comfort zone for mostly measured level of 60% and 50% relative humidity in SSE oriented classroom according to ASHRAE standard (Fig. 12 and 13).

Measurement results and votes of students on thermal sensation in the classroom in terms of humidity, temperature and air flow velocity levels are consistent except the relation of measured temperature and humidity values and the votes of students on these parameters. This can be the result of misunderstanding the meaning of the question on humidity by the students. This shows the importance of the definition of the questions to students during survey campaign.

In both classrooms temperature and humidity values are high and the survey also supports the measurement results. Most of the students stated that they had health problems as headache, throatache, stuffiness, etc. in the classrooms because of high temperatures which also

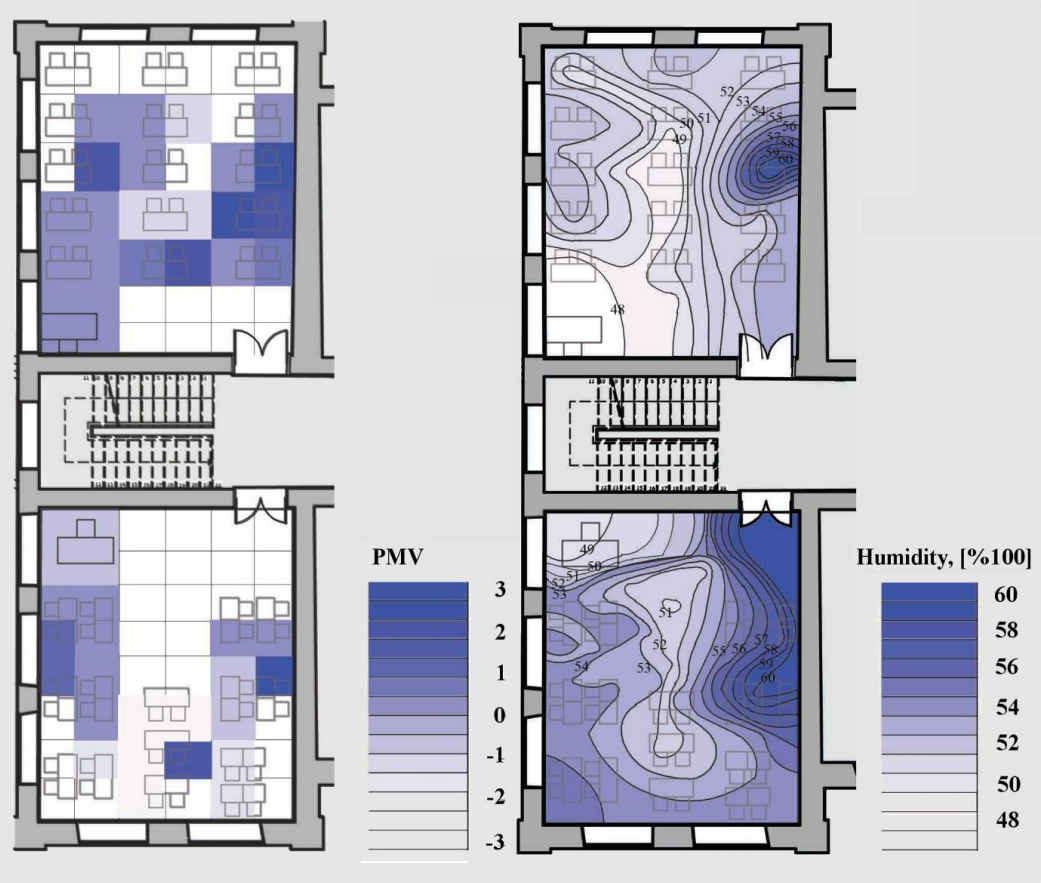

Figure 13. Comparison of relative humidity measurement results with questionnaire results of students in NNW and SSE classroom on 11.11.2015 through 11:15-12:15. (11 Kasım 2015 tarihinde 11:15 – 12:15 saat aralığında bağıl nem ölçümleri ve anket sonuçlarının karşılaştırılması)

6. CONCLUSION

In the context of the study thermal comfort conditions of the two, NNW and SSE oriented classrooms in historic Ulugazi Primary School was investigated by concurrently conducted survey process and measurement of temperature, relative humidity and airflow velocity process on 11 November 2015 in the morning, in order to diagnose the problems in terms of micro climatic conditions and their effect to students who have to spend most of their day time in healthy and comfortable interior environment for their qualified learning period.

decrease their concentration. The most important problem in the classrooms seems to be the insufficient amount of natural ventilation. The location of the new built blocks prevents the wind acting from west where most of the openings are located. Strategies on occupant behaviors for opening the right windows, in the right times for increasing natural ventilation efficiency have to be investigated by CFD simulations and measurements.

The hot interior environment is also caused by the heating system which was active during the measurement and survey campaign. Instead of making heating system

active whole day, intermittent heating strategies have to be improved in order to provide energy efficiency and thermal comfort conditions.

ASHRAE Standard recommends acceptable operating temperature in winter comfort zones for clothing level of 0.9 clo as 20.5-23^{0}C for humidity range of 60% and 20.7-23.9 ^{0}C for humidity range of 50%. In the 2 classrooms students clo values changed in the range of 0.29-0.47. Although the clothing levels are lower than the ASHRAE reference clo level students still felt uncomfortable from the hot environment in the two classrooms. But for these clo levels and comfort zone humidity and temperature values have to be investigated as a future study.

Finally, non-destructive tests on thermal comfort are an essential issue on the refurbishment of historic buildings. Unlike, new constructions, interventions on upgrading thermal performance of old buildings having historical, monumental and artistic values are a complicated issue. In this research, the importance of surveying regarding to temperature, relative humidity, air velocity and thermal comfort is highlighted prior to any kind of interventions in the context of energy efficiency.

REFERENCES

1. Corgnati, S.P., Filippi, M. and Viazzo, S. "Perception of the thermal environment in high School and university classrooms: Subjective Preferences and Thermal Comfort", ***Building and Environment***, 42: 951–959, (2007).
2. Teli, D., Jentsch F. M. and James, A. B. P. "The role of a building's thermal properties on pupils' thermal comfort in junior school classrooms as determined in field studies", ***Building and Environment***, 82: 640-654, (2014).
3. Theodosiou, T.G. and Ordoumpozanis, K.T., "Energy, comfort and indoor air quality in nursery and elementary school buildings in the cold climatic zone of Greece", ***Energy and Buildings***, 40: 2207–2214, (2008).
4. Allard, F., "Natural Ventilation in Buildings: A Design Handbook", ed. Matheos Santamouris and Francis Allard, ***Earthscan***, ISBN: 1873936729, London, 978, (1998).
5. Mendell, M.J. and Heath, G.A., "Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature", ***Indoor Air***; 15: 27–52, (2005).
6. Dimoudi, A. and Kostarela, P., "Energy monitoring and conservation potential in school buildings in the climatic zone of Greece", ***Renewable Energy***; 34(1): 289-296, (2009).
7. Dascalaki, E.G. and Sermpetzoglou, V.G., "Energy performance and indoor environmental quality in Hellenic schools", ***Energy and Buildings*** 43: 718–727, (2011).
8. Della Torre, S., "Economics of planned conservation", Integrating aims - Built heritage in social and economic development, ***Aalto University, Centre for urban and regional studies publications***, Helsinki, (2010).
9. Della Torre S. and Moioli R., "Designing an active monitoring system: the Planned Conservation Project in Monza and Brianza Province'', ***6th Seminar on Urban Conservation – Measuring Heritage Conservation Performance***, Recife, Brazil, 142 - 148, (2011).
10. Şenyurt, O., "1923-1960 / İzmit - Cumhuriyet'in tanıkları binalar ve kentten haberler", ***TMMOB Mimarlar Odası Kocaeli Şubesi***, ISBN: 9944899968, İstanbul, (2010)
11. Türkiye İstatistik Kurumu – Total energy consumption by sectors and usage areas, 2005 [online]. [Retrieved Date 2015-02-27] http://www.tuik.gov.tr/
12. Türkiye İstatistik Kurumu – Education Statistics, 1997-2014 [online]. [Retrieved Date: 2015-06-12]. http://www.tuik.gov.tr/
13. V. Pracchi and Rosina, E., "Protecting historical buildings doesn't mean only to respect their appearance", ***3rd European Workshop and training day on cultural heritage EWCHP,*** Bolzano/Bozan, Italy, 211-217, (2013).
14. Kishalı, E. and Bayraktar, N. T., "Evaluation of the studies for assessment of earthquake damages on historical monumental structures by non-destructive tests", ***5th International Earthquake Symposium***, Kocaeli, 127 – 135, (2015).
15. Binda, L., Saisi, A. and Tiraboschi, C. "Investigation procedures for the diagnosis of historic masonries", ***Construction and Building Materials***, 14: 199 – 233, (2000).
16. Ramos L.F., Marquesa L., Lourenço P.B., De Roeckb G., Campos-Costac A. and Roqued J., "Monitoring historical masonry structures with operational modal analysis: Two case studies", ***Mechanical Systems and Signal Processing***, 24: 1291–1305, (2010).
17. ASHRAE 2005 (SI Edition), "American Society of Heating, Refrigerating and Air-Conditioning Engineers Handbook Fundamentals SI Edition, F08- Thermal Comfort", (2005).
18. Haddad, S., King, S, Osmond, P. and Heidari, S., "Questionnaire design to determine children's thermal sensation, preference and acceptability in the classroom", ***PLEA2012 - 28th Conference, opportunities, limits & needs towards an environmentally responsible architecture Lima***, Perú, (2012).
19. Tuncer, K., "Isıl Konforun Fanger Yöntemiyle İncelenmesi", ***M.Sc. thesis***, Fen Bilimleri Enstitüsü, Gazi University, Ankara, (2006).
20. Yılmaz, Z. and Oral, G.K., "Yapı kabuğu ısı yalıtım değerinin yapı formuna bağlı olarak belirlenmesi için bir yöntem önerisi", ***Yapıda Yalıtım Konferansı***, İstanbul, 153-163, (1999).
21. T.C. Orman ve Su İşleri Bakanlığı, Meteoroloji Genel Müdürlüğü – Weather Centre –Weather: Average Conditions, 1970-2011- Kocaeli.
22. Kwok, A.G. and Chun, C., "Thermal Comfort in Japanese Schools", ***Solar Energy,*** 74: 245–252, (2003).
23. Yaşar, Y., Pehlevan, A. and Altıntaş, E., "İlköğretim dersliklerinde termal konfor araştırması", ***8th Ulusal Tesisat Mühendisliği Kongresi***, İzmir, 199-208, (2007).
24. Buratti, C. and Ricciardi, P., "Adaptive analysis of thermal comfort in university classrooms: Correlation between experimental data and mathematical models", ***Building and Environment***, 44: 674–687, (2009).
25. Ogoli, D. M., "Thermal comfort in a naturally-ventilated educational building", ***ARCC Spring Research Conference***, Eugene, Oregon, 19 – 26, (2007).