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IEQ Standard Implementation Methodology

Project Partners

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NOMENCLATURE

Abbreviations

AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BS	British Standard
CEEB	Centre for Energy and Environment Building
CCT	Correlated Colour Temperature
CFL	Compact Fluorescent Lamp
EML	Equivalent Malanopic Ratio
HVAC	Heating, Ventilation, and Air-Conditioning
IAQ	Indoor Air Quality
IEC	International Electrotechnical Commission
IEQ	Indoor Environmental Quality
IS	Indian Standard
ISHRAE	Indian Society of Heating, Refrigerating, and Air-Conditioning Engineers
ISO	International Orgnisation for Standarisation
NBC	National Building Code
NC	Noise Criteria
NIC	Noise Isolation Class
OAB	Old Administrative Building
PM	Particulate Matter
RB	Residential Building
RH	Relative Humidity
RSPM	Respirable Suspended Particulate Matter
SBS	Sick Building Syndrome
TVOC	Total Volatile Organic Compound

Symbols

CH_2O	Formaldehyde
CO	Carbon Monoxide

CO_2	Carbon Dioxide
D_w	Weighted Difference Level
D	Sound level Difference
$D_{nt,w}$	Weighted Standardisation Level Difference
$L_{Aeq, T}$	A- Weighted equivalent sound pressure level in dB Measured over a period of time T.
NO_2	Nitrogen Dioxide
O_3	Ozone
SO_2	Sulphur Dioxide
RT	Reverberation Time
Units	
°C	Degree Celsius
µg	Microgram
clo	Clothing Insulation
CFU	Colony Forming Units
dB	Decibel
$D_{nt,w}$	Weighted Standardisation Level Difference
Hz	Hertz
K	Kelvin
L	Lux
m	Meter
met	Metabolic Rate
Pa	Pascal
ppm	Parts Per Million
s	Second
W	Watt

ABSTRACT

Indoor environmental quality indicates the condition of environment inside the building which is defined and determined by factors such as thermal comfort, indoor air quality, acoustic comfort and lighting comfort. These factors significantly affect the productivity and well-being of occupants in an indoor environment. In the year 2016, ISHRAE released India's first Indoor Environmental Quality (IEQ) Standard (ISHRAE Standard-100001:2016). Above mentioned factors as referred as elements in the standard. The IEQ standard includes definitions for the elements affecting human health and comfort, threshold values of parameters contributing to these elements, specifications of measurement instruments and measurement methodology.

The present research project demonstrates review of India's IEQ standard, incorporate preliminary findings from a pilot study to understand and evaluate implementation methodology in buildings and also review the availability of instruments at Indian as well as international market. The pilot study is being investigated at Jaipur and Chennai for a year (June 2017 to May 2018) to cover all seasons. Experimental investigation of IEQ parameters at Jaipur are being carried out at three buildings, located in composite climatic zone. The first building is situated in an area with rich natural vegetation, away from heavy traffic and the second one is nearer to the roadway. The first building covers a total area of 1400 square meters distributed over 3 floors, having 25 rooms, and offer 66 types of potential occupant locations. Whereas, the second building covers a total area of 162 square meters with only 1 floor, 3 rooms, and 10 types of potential occupant locations. Both buildings are situated within MNIT Jaipur campus have shared as well as individual offices, laboratories and classrooms in which some are air-conditioned, and others are unconditioned spaces. The third building is residential apartments have 3 floors, only top floor apartment is used for the study, covers a total area of 125 square meters with 2 bedrooms, 1 livingroom, 1 kitchen and 6 types of potential occupant locations. Whereas the IEQ investigations at Chennai were carried out in diverse end-use buildings which include commercial, office, residential and institutional buildings. A total of 10 different buildings were selected

which included 2 commercial buildings (one computational room and one departmental stores), 3 institutional rooms (2 student offices and a laboratory), 4 office buildings (including 2 conference halls) and 3 residences. Out of the different buildings, one office (O2) and two residences (R2 & R3) were located near roadway and rest all buildings were located away from road traffic in a thickly vegetated area. As suggested in ISHRAE's IEQ standard, an occupant satisfaction survey was also conducted by using a seven-point scale for all IEQ parameters along with measurements.

The results show the majority of the IEQ parameters at both locations in all buildings have been found to be meeting the minimum threshold. This research project, besides, raising and offering clarity about the method of taking measurements, also presents comments on the availability of instruments required as per the standard. It suggests the necessity of some clarifications and revisiting accuracy and resolution of some measuring instrument with justifications.

Keywords: Indoor environmental quality, indoor air quality, thermal comfort, lighting comfort, field study, occupant survey

CHAPTER 1

INTRODUCTION

1.1 Indoor Environmental Quality

The healthy and comfortable indoor environment is primary requirement of the occupants as they spent most of their time in indoor. IEQ is affected by building location, orientation, climatic conditions, occupant behavior and building systems and typology. There has been a clear association between IEQ and the sense of well-being, health, productivity. Indoor air quality (IAQ) has gained much interest in the recent years as it can result in variety of adverse health outcomes ranging from headache and allergies to respiratory illness and even cancer. Furthermore, temperature and humidity at too high and low level, excessively bright or dim and deficient lighting system, interrupting high noise level leads to increase in mental and physical stress level in the human body which causes health problems such as concentration impairment, memory loss, digestive problem, sleep disorder etc.

Thermal Comfort is defined by ASHARE 55 as “the state of mind which express the satisfaction with thermal environment” (ASHRAE Std. 55, 2013). It relates to the physical factors in conditioned as well as naturally ventilated environments. Thermal comfort is strongly correlated with building energy consumption (Djongyang et al., 2010). Thermal comfort constitutes of physical environmental parameters such as mean radiant temperature, room air temperature, relative humidity, air movement, floor surface temperature etc. Further personal parameters metabolic rate and clothing valve also affect thermal comfort. It is the most preferred element in comparison to indoor air quality, acoustic comfort and lighting comfort (Frontczak et al., 2011).

According to ASHRAE (Standard 62-1989), an acceptable IAQ can be defined as (a) air in which there are no known contaminants at harmful concentrations, and (b) air with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. The level of satisfaction and acceptability (80%) indicates that conditions do not have to be unanimously or universally applicable. IAQ is recognized to cause chronic and acute effects on

occupant health. It is directly related to the concentration of pollutants and ventilation rates, which is in turn in causes Sick Building Syndrome (SBS) symptom. Indoor air pollutants mainly consist of particulate pollutants ($PM_{2.5}$, PM_{10}), gaseous pollutants (CO_2, CO, volatile organic compounds, formaldehyde, SO_2, NO_2, and O_3 etc.) and biological pollutants (bacteria, fungi, mould, pollen, animal dander, mites, virus etc.). IAQ standards have been set by both national and international organizations like Occupational Safety & Health Administration (OSHA), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), National Institute for Occupational Safety and Health (NIOSH), World Health Organization (WHO) which is used in many countries. Outdoor air plays a significant role on IAQ when no major indoor pollutant sources are present.

Improper lighting conditions such as too bright or too dark can create visual discomfort. Lighting comfort directly affects the occupant's work productivity and efficiency. It is a subjective measure and directly dependent on factors like illumination, the risk of glare, luminous spectrum, brightness and luminance (CEN, 2012). A proper visual environment condition causes an increment in the productivity and well-being of the building occupants (Serghides et al., 2015). The parameters of lighting comfort are illuminance, circadian lighting design, uniformity of illuminance and ratio of illuminance of task area to immediately adjacent surroundings. Useful Daylight Illuminance (UDI) and Daylight Autonomy (sDA) also affect the lighting comfort and energy consumption.

The acoustic comfort can be defined as absence of any uncomfortable noise within the indoor environment. The background or unnecessary noise must be minimized so as to support the acoustics in order to provide high speech intelligibility. For commercial buildings, it is considered as a critical IEQ element. Further, it is given higher preference by the occupants in classrooms and offices. Comfortable sound levels and speech privacy are considered as main requirements for occupants' satisfaction in work-places because it directly affects the work productivity and well-being (Jensen et al., 2005). Acoustic comfort is indirectly related to energy consumption. For example, to achieve more external and internal

sound insulation building occupants have a tendency to close the window and this could reduce the natural ventilation effect and causes higher cooling energy required to keep thermal comfort. Noise criteria, noise isolation class and reverberation time are the parameters of acoustic comfort.

In the year 2016, ISHRAE released India's first IEQ Standard. In this standard thermal comfort, indoor air quality, acoustic comfort, and lighting comfort are defined as elements of IEQ and they have been further divided into parameters.

Figure 1.1 Elements of IEQ

Standard includes definitions for the elements affecting health and comfort, threshold values of parameters contributing to these elements, measurement methodology, specifications of measurement instruments and satisfaction survey. The threshold values of parameters have been defined as three levels such as Class A (aspirational), Class B (acceptable) and Class C (marginally acceptable). Class A level is comparable with the worldwide accepted international standard. Since this standard has been applicable to a diverse range of buildings from unconditional residence units to large air-conditioned commercial complexes so some of the parameters are excluded in Class B and Class C.

Figure 1.2 Levels of threshold values

1.2 Objective

Evaluating the ease of implementing ISHRAE's IEQ standard. In 2016, ISHRAE has launched the India IEQ standard. Successful implementation of this standards need pilot testing. It is important to identify the critical difference between intent and practical implementation of this standard in real buildings. This investigation would be extremely useful in providing feedback to the IEQ standard team for improving it as needed. It would also help in identifying bottleneck for implementation and possible ways for removal of the same.

1.3 Approach

The following steps have been followed to meet the Objectives:

a) Evaluation of availability of instrumentation to comply with the ISHRAE Standard- 10001:2016 along with current cost. The standard specifies accuracy, resolution and sensor type for the instruments of different parameters. The study compares different instruments available in Indian as well as international market on the basis of compliance with the ISHRAE Standard- 10001:2016. In addition, comment on various sensing technologies suitable for different type of measurement format such as continuous monitoring, spot measurement, lab-based tasting etc.

b) Conduct measurement as specified in the standard in identified end-user applications (e.g. office, residence, mall, institution building) in more than one climate zones (at least two buildings in one climate zone). Report the observations and issues arising during measurement and necessary suggestions for strengthening measurement protocol.

c) Record, analyzed and report the IEQ parameter measurements.

d) Reporting the comments and necessary suggestions with clarifications on IEQ assessment.

1.4 Organisation

Some clarifications and corrections regarding some possible typos have been identified and purposed as erratum and addendum for the ISHRAE Standard-10001:2016. Erratum and addendum are specified in chapter 2. Availability of instruments is discussed in chapter 3. Methodology adopted along with site as well as measurement location selection, and instruments used for IEQ pilot investigation are presented in chapter 4. IEQ pilot investigation results are discussed in chapter 5. Results based on both monthly and seasonal variation of IEQ parameters are presented. Chapter 6 contains conclusions and recommendations for measurement methodology. Further, future study requirements are also presented in Chapter 6.

1.5 Literature Review

1.5.1 Ahn et al.

Ahn et al., (2017) examined the indoor air quality and working performance of cooling system of partition room (in terms of temperature distribution, ventilation effectiveness, energy consumption and thermal comfort) under different ventilation strategies (mixing and displacement). Simulation result reported the strong influence of ventilation strategy on temperature distribution and air freshness. As compared to mixing ventilation, the energy consumption in displacement ventilation (for single diffuser) was observed lower. However, mixing ventilation was also found energy saver

for separate diffuser for each partitioned space.

1.5.2 Al-hemoud et al.

Al-hemoud et al., (2017) compared the indoor air quality in schools for urban and industrial sectors, in terms of CO_2, NO_2, SO_2, H_2S, formaldehyde and acetaldehyde, TVOC and PM10. The data thus obtained was analysed for seasonal,

zone and climate variations using different statistical tools (T-test, one-way ANOVA, two-way ANOVA and linear regression). One-way ANOVA reported significant seasonal variations in NO_2, H_2S, formaldehyde, and acetaldehyde whereas two-way ANOVA identified significant location variations in TVOC, PAHs, and BDE-209. AC filters were recommended for dust analysis and measurement of typical indoor pollutants.

1.5.3 Cheng et al.

Cheng et al., (2017) investigated indoor air quality in nine buildings equipped with central air conditioning system operating under different climate zones (cold, hot summer and winter, mild) of China. The performance of buildings was assessed in terms of indoor thermal environment, CO_2 concentration (560-997 ppm), formaldehyde (0.02-0.31 mg/m^3) and TVOC (0.074-0.636 mg/m^3). Based on theoretical analysis, a mathematical model was also proposed providing quantitative analysis of the requirement of fresh air of underground floor with reference to above ground floor of same building.

1.5.4 Irshad et al.

Irshad et al., (2017) evaluated the performance of thermal comfort system in terms of subjective and objective measurement for a test room equipped with PV and thermoelectric air duct system. For the current variation 2A-6A, the thermal response of occupants was observed to change from slightly warm to cool. Also, the overall PMV predicted %, dissatisfied indices and acceptability vote obtained from more 90% of the occupants were reported thermally satisfied. Moreover, the cooling system was found efficient in terms of energy consumption, reliability, and maintenance.

1.5.5 Kontes et al.

Kontes et al., (2017) discussed the role of thermostats in monitoring of thermal comfort in indoor spaces and based on the outcomes, an experimental simulation protocol was developed to meeting the required thermal environment via real-time measurements considering various controlled parameters (Relative humidity, illuminations, CO_2 level, flow velocity, building design etc.) and

boundary conditions. Various comfort indices and models were analysed for the assessment and development of thermal comfort standards and their implications in real practice.

1.5.6 Mishra et al.

Mishra et al., (2017) studied thermal comfort perception of students in a classroom during the heating season. Based on two weeks' observations, the thermal sensation vote was reported to be different ($p < 0.05$) for different time points (10, 20 and 45 min.). Prior to the lecture, the student's perception was found varying based on the outside and operative temperature, gender and occupant origin. However, a significant difference was observed after indoor-outdoor transition during the second week of observations at 1.5°C lower set point. Moreover, the thermal environment was adopted gradually at 20 minutes of post-transition.

1.5.7 Sheng et al.

Sheng et al., (2017) studied air purification effect of clean air heat pump through sensory monitoring of air quality and chemical measurement of TVOC in a room having combined polluting effects of human bio-effluents and building materials. The outdoor air supply rate was reported to reduce by 76% whereas the single pass efficiency of removal of indoor air pollutants was calculated to be 92% at regeneration temperature of 60°C. Further, no TVOC was observed on desiccant wheel of clean air heat pump.

1.5.8 Sun et al.

Sun et al., (2017) carried out indoor air quality in residential area of Tianjin (China), in terms of formaldehyde, PM 2.5, PM 1, PM 0.1 and TVOC under normal and closed conditions. As compared to normal conditions, the average values of all pollutants were observed higher in closed conditions. Moreover, the outdoor particles and indoor activities were reported to have a significant impact on indoor PM.

1.5.9 Vilčeková et al.

Vilčeková et al., (2017) conducted the experimental assessment of IEQ parameters such as relative humidity, indoor temperature, and CO_2 along with occupant satisfaction survey. The study was conducted in university classrooms for 9 weeks of summer semester as well as 9 weeks of the winter semester. The instruments were fixed 1.1 above ground and placed at the center of the classroom. The mean values of air temperature found for winter and summer season were 23.1°C and 24.8°C respectively. Similarly, mean values of relative humidity found for winter and summer season were 41.15 % and 36.28 % respectively. Also, the mean values of CO_2 concentration found for winter and summer season were 1315.88 ppm and 1094.62 ppm (5% reduction) respectively.

1.5.10 Kumar et al.

Kumar et al., (2016) conducted field study to investigate the comfort boundaries given by ASHRAE at three different ranges of indoor air velocities (up to 0.2 m/s, 0.2 m/s - 0.5 m/s, 0.5 m/s – 1.5 m/s) in composite climate of India. The field study was done on 32 naturally ventilated buildings, 2610 total samples were collected over a span of 4 years. Class-II protocol of field measurement was used to record the surrounding conditions of occupants. Extended comfort temperature at elevated airspeed was calculated by the method given by ISO-7730 and ASHRAE 55-2013. The results showed new extended boundaries of acceptable zone by taking into account diverse adaptations including the part of air velocity to increase comfort temperature.

1.5.11 Aries et al.

Aries et al., (2015) presented the review of the effects of daylight on occupant health. The results showed the effect of daylight can be psychological and physiological. Also, the occupant health significantly associated with daylight potential. Further, the study stated that the building occupant spends the 90% of their time in indoors and often in contact with poor lighting conditions. The amount of daylight at the indoor (open window) was found to be higher than outdoor, which affects the occupant health more.

1.5.12 Dhaka et al.

Dhaka et al., (2015) conducted the field study in 30 naturally ventilated buildings on the basis of thermal comfort at composite climate of India. The buildings included office as well as residential buildings. The occupant satisfaction survey also conducted to analysed preference and sensation for relative humidity air velocity and room temperature. Class-II protocol of field measurement was used to record the surrounding conditions of occupants. The results showed a strong correlation between indoor temperature condition with outdoor temperature condition. Including all data for every season gave the neutral temperature at 27.2 °C and it was directly affected by the seasonal difference. Occupant satisfaction for thermal comfort was found to be 80% and 90% which was found to be higher as compared with limit defined by ASHRAE.

1.5.13 Fabbria et al.

Fabbria et al., (2015) stated that improve in relationship between building IEQ and energy performance is an important factor. Fabbria (2015) conduct IEQ investigation in low energy performance building which consumes less than 25 kWh/m^2year and lays in Class A+ (according to STN EN 15251). The instrument was placed at center of each room and also conditions of both heating and cooling season was covered. The results showed that it not necessary that low energy performance building can give a better IEQ, especially for the summer season.

1.5.14 Sakhare et al.

Sakhare et al., (2014) reviewed and analysed different standard of IEQ and investigated the different assessment models and IEQ contributing elements. The study also analysed the multiparametric comfort to enhance the work productivity and occupant's health. The study concluded the prioritization of IEQ elements on the basis of different literature and stats the priority of IEQ elements in descending order was found to be thermal comfort, acoustic comfort, IAQ and lighting comfort. Furthermore, Assessment of thermal comfort, acoustic comfort, IAQ and lighting comfort was found to be necessary to achieve comfort on the basis of IEQ. The occupant satisfaction survey along with physical measurement of parameters was found to be the most effective way to examine the IEQ elements.

1.5.15 Chithra et al.

Chithra et al., (2012) conducted an investigation of IAQ parameters in naturally ventilated classrooms of school building situated near to roadway at Chennai city for both winter and summer season. The instruments were placed at center of room and 1 m above the ground level. The average value of indoor CO, PM 1, PM 2.5 and PM 10 for winter and summer seasons found to be 0.10 ± 0.18, 43 ± 24, 61 ± 29, 149 ± 69 µg/m3 and 0.11 ± 0.14, 18 ± 9, 32 ± 16, 95 ± 61 µg/m3 respectively. The RSPM found to higher in winter season as compared to summer season. The higher value of PM 10 was found in indoor as compare to outdoor which was found to be due to indoor activities of occupants in the classrooms. PM 1, PM 10 and CO concentration were found too high due to higher contribution of outdoor concentrations.

1.5.16 Huang et al.

Huang et al., (2012) conducted field survey study to investigate the comfort range of IEQ elements such as indoor thermal, lux level, and acoustic comfort along with occupant satisfaction survey. The study was carried out at Office room size 3×3×3 m^3 with center table of Tsinghua University in Beijing with 120 different occupants. The measurements were taken 1 m away from the walls and close to occupant sitting. The results showed that the thermal comfort and acoustic comfort plays major role in acceptance of IEQ. The range of comfortable operative temperature, illuminance, and noise level were found to be 20.9°C to 30.4°C, above 300 Lux and below 49.6 dB reactively.

1.5.17 Kulshreshtha et al.

Kulshreshtha et al., (2010) conducted a competitive investigation of the IAQ parameters such as respirable suspended particulate matter, NO_2, CO and SO_2 in households of urban slums and controlled sites in Delhi. Further, a spirometry test was conducted on occupant to find the incidence of ARI. Measurements were conducted in both summer and winter seasons. Measurement time was between 10:00 to 16:00 during a day. To find the symptoms of sick building syndrome occupant interview surveys were also conducted. The results showed that the

maximum indoor air pollutants concentrations were found during winters in households which associated respiratory diseases like wheezing, breathlessness, phlegm, and coughs among occupants, especially in women. Due to the efficient dispersion of pollutants in summer the concentrations of pollutants were found to be lower. The NOx concentration sources were found to be gas and kerosene stoves in indoor and vehicular exhausts in outdoor.

1.5.18 Lee et al.

Lee et al., (2010) conducted the study compared IEQ elements such as thermal comfort, lighting comfort, and IAQ within the 5 different office types in LEED certified buildings. The study also related the job performance and environmental satisfaction of employees. The five different types of offices were private shared, private enclosed, open-plan with low cubicle less than 50 and open-plan with higher cubicle over 50, and open-plan without partitions. This study took data from CBE database along with online occupant satisfaction. Total 3533 surveys were conducted. Job performance was found to be enhanced by good IAQ in individual office as compared with both lower and higher cubical. Higher cubical showed the less satisfaction on the basis of lighting comfort as compared to remaining four office types. Also, thermal comfort was found to be equally affected the job performance and environmental satisfaction in all 5 types of offices.

1.5.19 Lai et al.

Lai et al., (2009) investigated the IEQ parameters on32 residential apartments with 125 occupants in Hong Kong. Four IEQ parameters including carbon dioxide concentration operative temperature, illumination level, and equivalent noise level analyzed at the sampling locations which were the activity area of each occupant. Measurements were conducted for 15 minutes at each measurement locations. Based on the total occupant's response both indoor thermal comfort and acoustic comfort have dominantly affected the acceptance of IEQ as compare with lighting comfort and IAQ. The acceptable range of operative temperature was found to be up to 29.8 °C by using clothing adjustment. The acceptance of equivalent noise level and Lux level were found to be up to 70 dBA and increase gradually 100 Lux to 500 Lux respectively.

1.5.20 Wong et al.

Wong et al., (2008) investigated the IEQ parameters in offices in Hang Kong with 293 different occupants. The IEQ parameters such as operative temperature, equivalent noise level, carbon dioxide concentration, and illumination level along with occupant satisfaction were analysed using multivariate logistic regression model. The results represented that the above four parameters had significantly affect the overall comfort in IEQ. The relative significance of IEQ elements on the basis occupant questionnaire stats the priority of IEQ elements in descending order was found to be thermal comfort, air quality, and acoustic comfort illuminance level. Occupant satisfaction was found to be 80% for good IEQ conditions and it can drop to 40%.

1.5.21 Nasrollahi et al.

Nasrollahi et al., (2007) investigated the Indoor Environment Quality at 6 office building in Tehran (Iran). The main focus of the study was thermal comfort and did only occupant satisfaction based study. The occupant satisfaction questionnaire was prepared on the basis of survey questionnaire of Sick Building Syndrome (SBS) used by the Building Research Establishment (BRE) and Centre of the Built Environment (CBE) at the University of California, Berkeley. In the questionnaire satisfaction with a condition such as temperature, the condition of different seasons, ambient conditions, office layout and personal adjust and control in workplace were added. The results show overall satisfaction in different buildings were 25% and 22% in winter and summers reactively and concluded that the thermal comfort directly affects the overall IEQ satisfaction.

1.5.22 Begemann et al.

Begemann et al., (1997) investigated long-term responses of occupant of window zone of typical office buildings. The results showed that most occupants prefer the day-light over artificial light. Also, occupant prefers most lighting as compared with threshold defined the different standards. Further, the biological light requirement and visual light requirement were found to be different from one another. The effects of visual performance and circadian cycles affect differently to different occupants.

1.5.23 A. R. M. Nasir et al.

A. R. M. Nasir et.al (2011) investigated the indoor environment Quality at different places. The main focus of the study was on noise pollution. Noise pollution from a scientific definition is the signal that does not give any information and the strength that changes dramatically over time, while the general definition is a sound that is not preferred that causes discomfort. This is when the sound reproduction occurs in places that are not appropriate with more than 80 decibels (dB). In addition, the effects of noise pollutions are also affecting the ears (auditory effect) and the outer ear (non-auditory effect). Effects of noise pollution caused by noise that is too loud in excess of 120 decibels (dB) can cause damage to the small hearing bones and can impair hearing permanently. It can also cause personal pain, dizziness, nausea and vomit, speech disturbances and behavior that can deteriorate the quality and efficiency of their work. Among the methods to achieve a comfortable sound level is to provide sound absorbing materials transferrable either through air or activity. Good design during construction could reduce noise through the use of appropriate materials.

1.5.24 Tiberiu Catalina et al.

Tiberiu Catalina et.al (2011) investigated the indoor environment Quality at different schools and study centers. The main focus of the study was on noise pollution. Noise may be very disturbing and may even weaken the student's intellectual performances. Noise pollution can originate from the outdoor environment (through the glazing area), from the ventilation system (noisy fans, high ventilation rate) or other adjacent interior spaces (corridors stepping noise or loud talking). The building envelope should ensure required sound insulation against both airborne noise and structure-borne noise. In general, sound insulation against airborne noise that is expected from the building envelope is of primary importance while the weak parts are the windows. Numerous studies have analyzed the sound transmission through closed or opened windows and the impact on the room acoustics. Most of them were orientated toward the sound insulation of the glazing or the impact of street noise on the indoor conditions. American National Standards Institute (ANSI) and EN15215 standard suggest that the background noise in the

classroom should be below 35 dB(A). The indoor acoustical comfort is generally evaluated by using the indoor sound pressure level (Lpi) as it was found in different research studies and it is considered the output parameter of the acoustic model prediction. A 100% fulfillment of the acoustic comfort is 30 dB(A) while the minimum comfort is of 60 dBA (value from where the study process cannot be accomplished anymore).

1.5.25 Tiberiu Catalina et al.

Tiberiu Catalina et al. (2011) investigated the indoor environment Quality, the main focus of the study was on Visual comfort. It is defined as "a subjective condition of visual well-being induced by the visual environment". Although the definition implies that there is a psychological dimension of comfort, a number of physical properties of the visual environment are defined and used to evaluate its quality in an objective way. Visual conditions are characterized by such parameters as luminance distribution, illuminance and its uniformity, glare, colour of light, colour rendering, flicker rate and amount of daylight. Daylighting contributes to a better IEQ and has a positive effect on an occupant's perception of productivity and performance. Daylight design requires a number of variable resources, among which the fenestration is the key piece. Design decisions need to be made early, so easy models are needed to be used for predicting the daylighting potential and to explore different scenarios of building design. The required lighting level is independent of season and its design value. The monthly average illuminance level (Ea) is considered the output parameter for the visual comfort. This level is established based on the average value obtained by the lux meter.

1.5.26 Li Huang et al.

Li Huang et al. (2011) investigated the indoor environment Quality, the main focus of the study was on thermal comfort. During the survey, mean daily outdoor temperatures ranged from 25.1°C to 28.8°C. Operative temperature was used as the indoor temperature index since it is comprised of both convection and radiation. The operative temperature in the survey ranged from 17.8°C to 31.4°C. The relative humidity ranged from 40% to 65%, with an average of 51%. The air velocity was 0.02 m/se0.42 m/s; among all the samples, the average value was 0.16 m/s and most

samples had an air velocity lower than 0.2 m/s. When the satisfaction level of the thermal environment was greater than 0, which indicated that subjects felt satisfied with the thermal environment, the operative temperature ranged from 20.9°C to 30.4°C. The highest level of satisfaction with the thermal environment occurred when the operative temperature was 25.7°C. From these results, it can be seen that even in an air-conditioned environment, subjects had a wide range of acceptable temperatures. The upper limit of 30.4°C was higher than the 28°C which was set as the upper limit in the Chinese design code for air-conditioned rooms in summer.

1.5.27 A.C.K. Lai et al.

A.C.K. Lai et al. (2009) investigated the indoor environment Quality, the main focus of the study was on carbon dioxide (CO2). The measured ranges of CO2 concentration (330–1500 ppm), horizontal illumination level (187–1522 lx) and equivalent sound pressure level (67–78 dBA) were approximated by geometric distributions. The geometric means (GMs) as well as geometric standard deviations (GSDs) for the levels of CO2, horizontal illumination, and equivalent sound pressure respectively were: GM = 600 ppm, GSD = 1.6 ppm; GM = 112 lx, GSD = 2.9 lx; and GM = 67 dBA, GSD = 1.1 dBA. Based on the regression coefficients determined from the field measurements, the correlations between the occupant acceptance and each of the environmental parameters were studied and found to be statistically significant. According to the survey results from 125 interviewees, 118 of them were satisfied with the IAQ, 115 with the visual environment, and 113 with the aural environment. For unsatisfactory CO2 levels, the occupants would open a window or turn on an extraction fan for fresh air supply. The choice of illumination level was task-related and dependent on the energy cost. As occupants had little control over the noise source outside their residential buildings, they expressed significant concerns about the noise control measures. Traffic noise and noises from neighborhood activities were the typical sources causing unsatisfactory aural environmental quality.

1.5.28 A. R. M. Nasir et al.

A. R. M. Nasir et.al (2011) investigated the indoor environment Quality, the main focus of the study was on particulate matter in Klang Valley. Suspended particles (PM10) are the particles with the size less than 10 1J. M, which could be

sucked into the lungs. PM, is a mixture of solids and liquid droplets floating in the air. PM10 are so small that they can get into the lungs, potentially causing serious health problems. It is an important indicator for assessing air quality in the Klang Valley. The guidelines have been proposed for air quality control in Malaysia which 150 μg/m3. Hazy conditions are said, when the level of suspended particles is twice greater than normal condition, while visibility or visible distance is less than 1 km and a relative humidity of less than 95%. Among the diseases often associated with the occurring haze problem is asthma attack. Asthma is a disease that occurs in the airways of individuals who are sensitive to stimuli from external factors. The disease is caused by the narrowness of the respiratory tract as a result of the movement of spastic bronchitis, swelling of the bronchial branches and excess mucus production. There are two types of asthma, extrinsic asthma caused by external factors such as eating dirt or dust in the air or the weather. Meanwhile, intrinsic asthma is caused by Indoor factors such as genetics, emotional tension or fatigue.

CHAPTER 2

ERRATUM AND ADDENDUM

2.1 Introduction

While reviewing ISHRAE IEQ standard, the research team found requirement of some clarifications and corrections regarding some possible typos. Also, there are some parts where some additional information is required. So both corrections and addition are purposed as erratum and addendum for the ISHRAE Standard-10001:2016.

2.2 Erratum

2.2.1 Major Corrections

The corrections for erratum are presented in Table 2.1

Page No./ Article No.	**Section**	**Proposed Corrections**	**Reasons & References**	**Type of correction/addition**
19/ Table 4	Threshold value of parameters of lighting comfort	Corrected table is given below in content no. 2.2.2	**Reasons:** Parameters should be self-explanatory	Addition of some literature along with threshold values of parameters of lighting comfort
21 / 5.2.5	Noise isolation applicable for class A Whereas in definition reference is given to section 5.2.4.1	'5.2.4.1' should be printed as '5.2.5'	**Reasons:** Title5.2.4.1 is absent	Correction in printing mistake
22/5.2.5	Title 5.2.5.1 and	Should be tabular form as content	**Reasons:** Title 5.2.5.1 and 5.2.5.2 should	Corrections to convert the

Page No./ Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
	5.2.5.2	no. 2.2.3 (Given Below)	be printed as 5.2.4.1.1 and 5.2.4.1.2 respectively which are of 5 digits & do not justify the title	texted part into tabular form
23 / Table 7	Mean radiant temperature is missing	**Parameter:** Mean radiant temperature **Methodology:** Shall be measured at 0.6m level for seated occupants and the 1.1m level for standing occupants.	**Reasons:** Methodology of Mean radiant temperature should be there	Addition of parameter and measurement methodology in the table
23 / Table 7	Vertical Air Temperature Difference is missing	**Parameter:** Vertical Air Temperature Difference **Methodology:** Shall be calculated by the arithmetic difference of air temperature measured at 0.1 m and 1.1 m level for seated occupant and air temperature measured at 0.1 m and 1.7 m level for standing occupant.	**Reasons:** Methodology of Vertical Air Temperature Difference should be there **Reference**: ASHRAE 55,2013	Addition of parameter and measurement methodology in the table
26 / Table 10	Accuracy is less than Resolution of TVOC **Resolution:** 0.01 ppm(22.9 µg/m3 equivalent to isobutylene) **Accuracy:** ± 0.005 ppm (115 µg/m3)	**Resolution:** 0.001 ppm (2.29 µg/m3 equivalent to isobutylene) **Accuracy:** ± 0.005 ppm (11.5 µg/m3)	**Reasons:** If we are going with Resolution: 0.01 ppm(22.9 µg/m3 equivalent to isobutylene), Accuracy: ± 0.05 ppm (115 µg/m3); the threshold value are <200µg/m3 and <500µg/m3 for class A and class B respectively, then the accuracy and resolution do not justify the threshold value	Correction in values of accuracy and resolution
26 / Table 10	Accuracy is less than Resolution of CH_2O	**Resolution:** 0.001 ppm (1.23 µg/m3)	**Reasons:** If we are going with Resolution: 0.01 ppm (12.28 µg/m3) Accuracy: ± 0.005 ppm (6.14 µg/m3); the	Correction in values of accuracy and resolution

Page No./ Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
	Resolution: 0.01 ppm (12.28 µg/m3) **Accuracy:** ± 0.005 ppm (6.14 µg/m3)	**Accuracy:** ± 0.005 ppm (6.14 µg/m3)	threshold value is <30µg/m3 and <100µg/m3 for class A and class B respectively, then the accuracy and resolution do not justify the threshold value	
26 / Table 10	Acoustic Comfort	Remark: a) Measurement should be taken using a level 1 or level 2 sound meters, set to read on "A" scale to record dB (A) b) Measuring equipment shall be able to perform Octave band and third Octave band analysis c) Measuring equipment shall conform to the accuracy requirement given in IEC 61672	**Reasons:** Point b) is necessary to give information about noise criteria reverberation time measurement	Corrections in the complete remark column of sound to add a point(b)
30/9.2	In thermal comfort 1. Radiant Temperature Asymmetry 2. Vertical Air Temperature Difference 3. Floor surface Temperature	Add below parameters in thermal comfort 1. Radiant Temperature Asymmetry 2. Vertical Air Temperature Difference 3. Floor surface Temperature	**Reasons:** As we have the threshold values of these parameters, so these parameters must be in the reporting table	Addition of 3 parameters in the table
Annex C.2	Lamp colour appearance groups	Find the title content no. 2.2.4 (given below)	**Reference:** EN 12464-1:2011,Table 3,(17)	Addition of colour appearance groups in the table

Table 2.1 Major Corrections for erratum

2.2.2 Threshold values for lighting comfort

Threshold values of parameters for lighting comfort shown in Table 2.2

Parameters	**Unit**	**Type of space**	**Classification**		
			Class A	**Class B**	**Class C**
Illuminance	**Table 5**				
Circadian Lighting Design	Equivalent Melanopic Lux (EML)		At least 250 EML is present within at least 75% of workstations	At least 250 EML is present within at least 75% of workstations	-
Uniformity of illuminance			Ratio of minimum illuminance to average illuminance within the task area should be at least 0.7	Ratio of minimum illuminance to average illuminance within the task area should be at least 0.7	-
Illuminance of the immediate surrounding areas			Ratio between a task area illuminance and immediately adjacent surroundings illuminance should be 3:1	-	-
Percentage of the task area meeting the required illuminance	%		Percentage of number of workstations meeting the required illuminance out of total number of workstations should be at least 90	Percentage of number of workstations meeting the required illuminance out of total number of workstations should be at least 80	Percentage of number of workstations meeting the required illuminance out of total number of workstations should be at least 80
Occupant Satisfaction	%		90	80	-

Table 2.2 Threshold values of parameters for lighting comfort

2.2.3 Noise Isolation Class

Building	**Type of space**	**Noise Isolation Class(NIC)**
Office	Between two offices	D_w of at least 38dB
	Where privacy is important	D_w of at least 48dB
	Cellular offices	NIC of at least 40dB
Residential	Partitions separating a water closet (WC) from a noise sensitive room	$D_{nt,w}$ of at least 38 dB
Hotels	Partitions and floors between rooms and corridors	$D_{nt,w}$ of at least 50 dB

Table 2.3 Threshold value Noise Isolation Class

2.2.4 Light Source and Melanopic Ratio

Light source and Melanopic Ratio corresponding to different CCT (K) shown in Table 2.4

CCT(K)	**Colour Appearance**	**Light Source**	**Melanopic Ratio**
2950	Warm	Fluorescent	0.43
2700		LED	0.45
2800		Incandescent	0.54
4000	Intermediate	Fluorescent	0.58

4000		LED	0.76
5450	Cool	CIE E (Equal Energy)	1.00
6500		Fluorescent	1.02
6500		Daylight	1.10
7500		Fluorescent	1.11

Table 2.4 Light source and Melanopic Ratio corresponding to different CCT (K)

2.3 Addendum

2.3.1 Major Additions

Required major additions in ISHRAE IEQ standard are presented in Table 2.5

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
Lighting Comfort Definitions				
11/3.4	Background Area	In indoor workplaces, particularly those devoid of daylight, a large part of the area surrounding an active and occupied task area needs to be illuminated. This area is known as the 'background area' should be a border at least 3 m wide adjacent to the immediate surrounding area within the limits of the space.	**Reference:** CIBSE, The SLL Code for Lighting (March 2012) //2.1.3.5(35)	Addition of definition in Lighting comfort definitions
11/3.4	Disability Glare	Glare that impairs the vision of objects without necessarily causing discomfort. Disability glare can be produced directly or by reflection	**Reference:** CIBSE, The SLL Code for Lighting (March 2012)//(296)	Addition of definition in Lighting comfort definitions
11/3.4	Discomfort Glare	Glare that causes discomfort without necessarily impairing the vision of objects. Discomfort glare can be produced directly or by reflection	**Reference:** CIBSE, The SLL Code for Lighting (March 2012)//(297)	Addition of definition in Lighting comfort definitions
11/3.4	Glare	Glare is the sensation produced by bright areas within the visual field, such as lit surfaces, parts of the luminaries, windows and/or roof lights. Glare shall be limited to	**Reasons:** Glare has been covered in survey form. But, neither it has been mentioned in definition nor anywhere in	Addition of definition in Lighting comfort definitions

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
		avoid errors, fatigue and accidents.	main section. **Reference:** CIBSE, The SLL Code for Lighting (March 2012)//2.1.5	
11/3.4	Reflected Glare	The variety of ill effects on visual efficiency and comfort produced by unwanted reflection in and the task area	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 1 LIGHTING AND NATURAL VENTILATION	Addition of definition in Lighting comfort definitions
11/3.4	Task Area	Partial area in the workplace in which the visual task is carried out. For places where the size and location of the task area are unknown, the area where the task may occur shall be taken as the task area.	**Reference:** EN 12464-1:2002 /3.2/5	Addition of definition in Lighting comfort definitions
11/3.4	Veiling Reflections	Specular reflections that appear on the object viewed and that partially or wholly obscure the details by reducing contrast	**Reference:** CIBSE, The SLL Code for Lighting (March 2012)//(314)	Addition of definition in Lighting comfort definitions
Acoustic Comfort Definitions				
11/3.5	Background noise	The sound pressure levels in a given environment from all sources excluding a specific sound source being investigated or measured	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	Addition of definition in acoustic comfort definitions
11/3.5	Broad Band Noise	Spectrum consisting of a large number of	**Reference:** NBC 2016 Part 8	Addition of definition in

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
		frequency components, none of which is individually dominant	BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	acoustic comfort definitions
11/3.5	Frequency	The number of cyclical variations per unit time. Frequency generally expressed in cycle per second and is also denoted as Hertz	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	Addition of definition in acoustic comfort definitions
11/3.5	Indoor Ambient Noise	Noise in a given situation at a given time, usually composed of noise from many sources, inside and outside the building, but excluding noise from activities of the occupants.	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions
11/3.5	Noise	Unwanted sound which may be hazardous to health, interferes with communication or is disturbing	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	Addition of definition in acoustic comfort definitions
11/3.5	Octave band	Band of frequencies in which the upper limit of the band is twice the frequency of the	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
		lower limit		definitions
11/3.5	Sound	A vibrational disturbance, exciting hearing mechanism, transmitted in a predictable manner determined by the medium through which it propagates. To be audible the disturbance shall have to fall within the frequency range of 20Hz to 20000 Hz	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	Addition of definition in acoustic comfort definitions
11/3.5	Sound level Difference, D	Difference between the sound pressure level in the source room and the sound pressure level in the receiving room.	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions
11/3.5	Sound Source	Equipment or phenomena which generate sound. Source room is the room containing sound source	**Reference:** NBC 2016 Part 8 BUILDING SERVICE – SECTION 4 ACOUSTICS, SOUND INSULATION AND NOISE CONTROL	Addition of definition in acoustic comfort definitions
11/3.5	Standardisation Level Difference, D_{nt}	Difference in sound level between a pair of rooms, in a stated frequency band, normalized to a reverberation time of 0.5 s for dwellings	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions
11/3.5	Third Octave Band	Band of frequencies in which the upper limit of the band is 2⅓ times the frequency of the lower limit	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions
11/3.5	Weighted Level Difference, D_w	Single number quantity that characterizes airborne sound insulation between rooms but which is not adjusted to reference conditions	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
11/3.5	Weighted Standardisation Level Difference, $D_{nt,w}$	Single number quantity that characterises airborne sound insulation between rooms	**Reference:** BS 8233:2014	Addition of definition in acoustic comfort definitions
13/4.2	Symbols	1. D-Sound level Difference 2. D_{nt}-Standardisation Level Difference 3. D_w-Weighted Level Difference 4. $D_{nt,w}$-Weighted Standardisation Level Difference 5. T-Reverberation Time	**Reasons:** These symbols are from above definitions	Addition of symbols
30 / 9.3	Format for reporting occupant satisfaction survey	Find the title 5 (given below)	**Reasons:** As we have the threshold values of occupant satisfaction parameters, so there must be a table for reporting of occupant satisfaction survey	Addition of table for reporting of occupant satisfaction survey
Annex C	Add literature on task area, immediate surroundings and background area	Find the title 4 (given below)	**Reasons:** Literature should be there for developing understanding of the parameter **Reference:** 1. EN 12464-1:2011 2. DIN EN 12464-1	Addition of literature in annex
Annex C	Glare	Find the title 5 (given below)	**Reasons:** Literature should be there for developing understanding of the parameter	Addition of literature in annex

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
			Reference: 1. NBC 2016 Part 8 BUILDING SERVICE – SECTION 1 LIGHTING AND NATURAL VENTILATION 2. CIBSE, The SLL Code for Lighting (March 2012) //2.1.3.4(34-35) 3. 'The lighting handbook' by 'Zumtobel lighting GmbH' 4. Lighting handbook INDALUX 2002	
Annex C	Recommended methodology to calculate lighting parameters	Find the title 7 (given below)	**Reasons:** An example is needed for clarification of methodology to calculate lighting parameters	Addition of an example in annex
Annex D	Sound Isolation	Find the title 8 (given below)	**Reasons:** Literature should be there for developing understanding of the parameter **Reference:** ISO 16283-1:2014(E)	Addition of formulas along with some methodology in annex
Annex D	Reverberation Time	Find the title 9 (given below)	**Reasons:** Literature should be there to developing understanding about the parameter	Addition of literature for calculation methodology in annex

Page No/Article No.	Section	Proposed Corrections	Reasons & References	Type of correction/addition
			Reference: ISO 3382-1:2009(E)	

Table 2.5 Required major additions for addendum

2.3.2 Occupant Satisfaction Survey

Format for reporting occupant satisfaction survey is shown in Table 2.6

Element	Occupant satisfaction (%)	Classification (Class A/Class B/Class C)	Remarks
Thermal Comfort			
Indoor Air Quality			
Lighting Comfort			
Acoustic Comfort			

Table 2.6 Format for reporting occupant satisfaction survey

2.3.3 Lighting Area

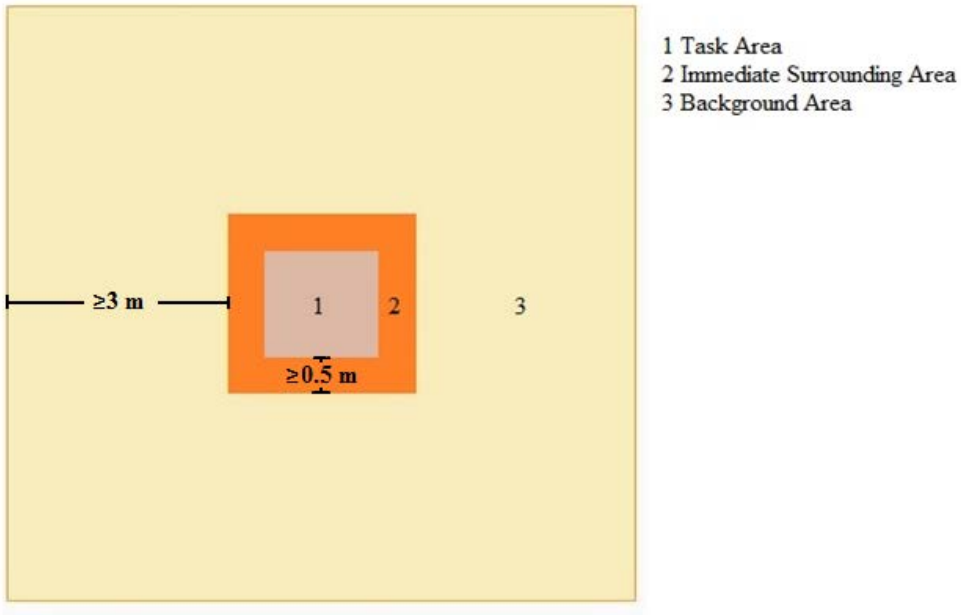


Figure 2.1 Task, immediate surrounding and background areas

- Area where the visual task is performing defined as the task area. The visually relevant elements such as background contrast, size of objects, presentation time and luminance of objects are used to determine the visual performance required for the visual task. The reference surface of the visual task can be vertical, horizontal or inclined.
- At least 0.5 m bandwidth area surrounding the task area within the field of vision is defined as the immediate surrounding area.
- Background area is defined as the band of at least 3 m wide adjacent to the immediate surrounding area within the limits of the space

2.3.4 Glare

Glare is the result of sudden large changes in brightness of the light source, which leads to lower efficiency of the vision. An occupant under the effect of glare fails to notice subtle changes and details of a scene. It is mainly classified into two types of Direct Glare and Reflected Glare

Direct Glare

Direct Glare is caused when within an occupant's field of vision, the luminaires of a room are without glare control thereby making the task area and surfaces very bright resulting in glare. The effects of it are fatigue, frequent mistakes and loss of concentration.

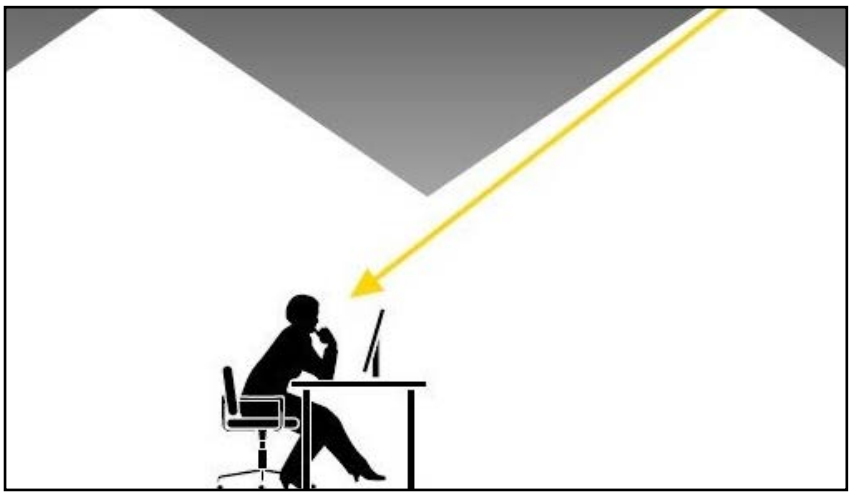


Figure 2.2 Direct glare

Reflected Glare

Reflected Glare is caused due to reflections coming from light sources or surfaces of excessive brightness which is the result of incorrect Luminaire arrangement and incorrect workstation position. The effects of it are fatigue, frequent mistakes and loss of concentration.

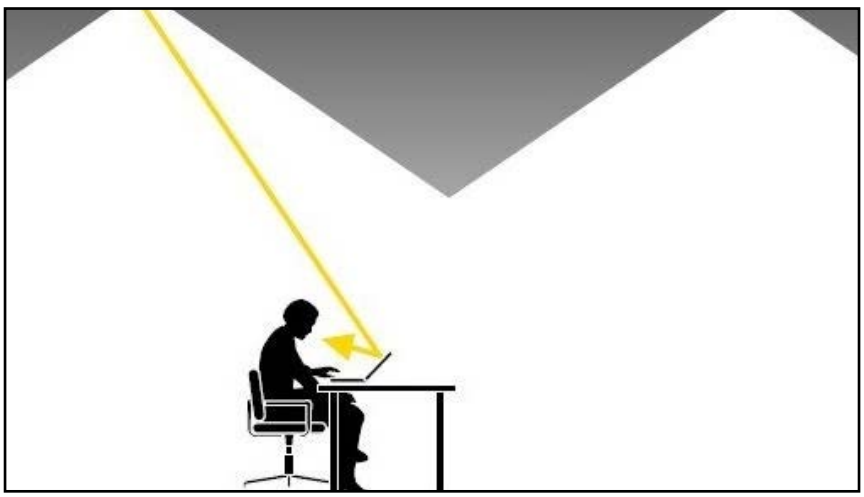


Figure 2.3 Reflected glare

In general, Glare mainly experienced either as physiological effect known as Disability glare or psychological glare known as Discomfort glare

Disability glare

Disability glare is direct impairment of visibility and visual capacity by the effect of glare. As an effect of glare occurs due to luminance from immediate background light source disability glare is happed. Discomfort does not necessarily cause by disability glare.

Discomfort glare

Discomfort glare is disturbance, which impairs our sense of wellbeing by the effect of glare. The level of discomfort occurs due to glare is depends upon size of glare source and the luminance. Discomfort glare does not necessarily impair object observation. As passing of time discomfort tends to increase and causes nervous tension and fatigue. Object observation impairment does not necessarily cause by discomfort glare

2.3.5 Calculation Method

Methodology to calculate lighting parameters

If the Illuminance at three points of task area are 515 Lux, 535 Lux, and 550 Lux, further the Illuminance at three points of immediate surrounding area are 430 Lux, 465 Lux and 495 Lux then

Illuminance of task area shall be calculated by averaging the measured illuminance within the task area

$$Illuminance = \frac{515 + 535 + 550}{3}$$

$$Illuminance = 533\ Lux$$

Uniformity of Illuminance shall be calculated by ratio of minimum illuminance to average illuminance within the task area

$$Uniformity of Illuminance = \frac{515}{533}$$

$$Uniformity of Illuminance = 0.9$$

Illuminance of the immediate surrounding areas shall be calculated by averaging the measured illuminance within the immediate surrounding areas

$$Illuminance of immediate surroundings = \frac{430 + 465 + 495}{3}$$

$$Illuminance of immediate surroundings = 463\ Lux$$

Ratio between a task area illuminance and immediately adjacent surroundings illuminance = $\frac{533}{463} = 1.15$

Percentage of the task area meeting the required illuminance

If in a conference room there are five occupants, the measured illuminance of their task areas are 510 Lux, 580 Lux, 455 Lux, 550 Luisnd 535 Lux. Thus 4 out 5 locations are meeting the threshold value, and then the Percentage of the task area meeting the required illuminance can be calculated by

$$Percentage of the task area meeting the required illuminance = \frac{4 * 100}{5}$$

$$= 80\ \%$$

2.3.6 Sound Isolation Class

Sound Level Difference

Difference in the energy-average sound pressure levels between the source and receiving rooms with one or more loudspeakers in the source room which is calculated using Formula

$$D = L1 - L\ 2$$

Where

L1 is the energy-average sound pressure level in the source room when its volume is larger than or equal to 25 m3 or the low-frequency energy-average sound pressure level (50 Hz, 63 Hz and 80 Hz bands only) in the source room when its volume is smaller than 25 m3;

L2 is, he energy-average sound pressure level in the receiving room when its volume is larger than or equal to 25 m3 or the low-frequency energy-average sound pressure level (50 Hz, 63 Hz and 80 Hz bands only) in the receiving room when its volume is smaller than 25 m3

Stan, ardized Level Difference

Level difference that is standardized to a reference value of the reverberation time in the receiving room and calculated using Formula

$$D_{nt} = D + 10 \log (T/T_0)$$

Where

T is the reverberation time in the receiving room;

T_0 is the reference reverberation time; for dwellings, $T_0 = 0.5$ s.

(The above article is same as specified in ISO 16283-1:2014 (E))

2.3.7 Reverberation Time

Reverberation is a phenomenon where the sounds bouncing off the reflective surfaces such as tables, windows, walls, floor and ceiling of a room intermix with each other. The time taken by these continuously bouncing off sounds to eventually fade away from the room is known as the Reverberation time and it is measured in octave or third-octave bands.

For the evaluation of the sound band it is not necessary to analyse the decay time till 60 dB, and can be analysed on a smaller dynamic ranges, such as the range of 5dB to 35dB below the initial level being labeled as T_{30} and the range of 5dB to 25dB below the initial level being labeled as T_{20}. The evaluation of these smaller ranges can be further analysed to extrapolate to measure the decay time over the full 60 dB ranges. So if we have to measure the decay time over 60 dB it will be calculated by the following arithmetic expressions: 3 x (time decay over 20dB) or 2 x (time decay over 30 dB).

(The above article is same as specified in ISO 3382-1:2009 (E))

CHAPTER 3

AVAILABILITY OF INSTRUMENTS

3.1 Introduction

The team has gone through various equipments available in India as well as world over. Specifications of these equipment have been examined and compared with the requirements spelled out in ISHRAE Standard 10001:2016. A master sheet of availability of instruments is presented in Annexure A.1. In many cases, MNIT and IIT Madras already are in possession of equipment complying with the requirements, which has been mentioned in the report as well. Narrative of the same is presented below:

3.2 Thermal Comfort

3.2.1 Air Temperature, Mean Radiant Temperature, Relative Humidity, Air Velocity

There are several instruments available at reasonable cost, for this purpose. MNIT Jaipur used Testo480**,** because it is fulfilling accuracy and resolution requirement and it is a single set of instrument along with tripod stand, can measure above parameters and includes Indoor Air Quality parameters like CO_2 and Illuminance also. Testo-480 is also suitable for long-term measurement with data logging in internal memory and SD card storage.

3.2.2 Floor Surface Temperature

There are several instruments available at reasonable cost, for this purpose. MNIT Jaipur used **Testo 905-T2** because it is fulfilling accuracy and resolution requirement and is suitable for measurements on uneven surfaces, large measuring range: Temperature measurements up to +500 °C is possible for a short time, extremely quick response time, convenient reading of measurement results on the swivel display.

3.2.3 Plane Radiant Temperature

This instrument is having limited availability. One product is found with Indian supplier is Lumasence Technology Denmark's product Radiant Temperature Asymmetry Transducer – INNOVA MM0036.

3.3 Lighting Comfort

3.3.1 Illuminance

There are several instruments available at reasonable cost, for this purpose. **Testo480** and **Lutron LX103** MNIT Jaipur have been used for our purpose because it is fulfilling our accuracy and resolution requirements. **Testo480** is a single set of instrument along with tripod stand, can measure above parameter and includes Indoor Air Quality parameters like CO_2 and thermal comfort parameters like air temperature, air temperature, relative humidity, air velocity also. Testo480 is suitable for long-term measurement with data logging in internal memory and SD card storage. **Lutron LX103** is pocket-sized and has a separate light sensor probe which allows user to measure the light at optimum position.

3.4 Acoustic Comfort

3.4.1 Sound

MNIT used **Lutron SL-4010**. IEQ standards preferred that measuring instrument shall conform to the accuracy requirement given in IEC 60804. **It may be noted that IEC 60804 code is replaced by IEC 61672. The same change needs to be made in the ISHRAE Standard.** In IEC 61672 accuracy is not in %, it is in terms of dB for different Frequencies (Hz). Accuracy and resolution of **Lutron SL-4010** are according to IEC 61672-1: 2013 Class 2. Equipment for measurement of Noise Criteria (NC value calculation) and Reverberation time measurement are quite costly (around Rs. 2,40,000) and could not be procured within the allocated budget.

3.5 Indoor Air Quality

3.5.1 CO_2

Finding instruments for CO_2 is not an issue, several options are available. MNIT used **Testo480** because it is fulfilling our accuracy and resolution requirements. **Testo480** is a single set of instrument along with tripod stand can

measure above parameters and includes lighting comfort parameter like illuminance and thermal comfort parameters like air temperature, air temperature, relative humidity, air velocity also. Testo480 is suitable for long-term measurement with data logging in internal memory and SD card storage.

3.5.2 CO

Finding instruments for CO is not an issue, several options are available. Testo350 available in MNIT and meet required accuracy and resolution. Testo 350 used for flue gases analysis and for flue gas analysis we have to fill which kind of fuel is burning, so Testo350 we cannot use for Indoor conditions.

ATS 103M by Applied Techno Systems Ltd. is most suitable option because it is fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle. Its price is also reasonable

3.5.3 PM 2.5 and PM 10

Finding suitable low-cost instrument for PM is a bit of challenge. Many manufacturers offer products meeting the accuracy, resolution and recommended technologies as per ISHRAE IEQ Standard. It has been noted that leading manufacturer, Graywolf and most of other companies are mentioning Counting Efficiency and Zero Count Level instead of accuracy and resolution.

Some product of other companies like BRAMC etc. are offering required resolution with reasonable price, but Accuracy is not according to requirement.

1080-A Professional is giving required resolution but the measuring principle and accuracy are not mentioned on brochures and supplies have not the information, it can also measure the CH_2O, SO_2, NO_2, and O_3, its cost is very high (Rs. 3,720,126).

Handheld Area Monitor by Applied Techno Systems Ltd. is most suitable option because it is fulfilling our accuracy, resolution requirements and it is according to preferred measuring principle. Its price is also reasonable.

Note: Most of the companies use terms like Counting Efficiency, Zero Count level, and Lowest Detection Limit etc. instead of accuracy and resolution. Gravimetric and beta attenuation methods are not available in handheld instruments.

3.5.4 TVOC

Finding a suitable low-cost instrument for TVOC is quite challenging. Many manufacturers offer products meeting the accuracy, resolution and recommended technologies as per ISHRAE IEQ Standard.

Gray Wolf's product (IQ610 Probe + Advance Sense PRO Display) also fulfilling accuracy, resolution requirement and it is according to preferred measuring principle but its cost is high (Rs.3,75,000).

Some product of other companies like BRAMC etc. giving required resolution and price is reasonable but Accuracy is not according to requirement.

Portable VOC Monitor in PID by Applied Techno Systems ltd.is the most suitable option because it is fulfilling our accuracy, resolution requirements and it is according to preferred measuring principle. Its price is also reasonable.

Note: Gas chromatography (GC) method is not available in handheld instruments.

3.5.5 CH_2O

Finding a suitable low-cost instrument for CH_2O is a bit of challenge. Many manufacturers offer products meeting the accuracy, resolution, **but not as per the technology recommended in the ISHRAE IEQ Standard**. Most of the products other companies are giving Electrochemical Sensor which is not according to preferred measuring principle. Gray Wolf's product PM801 also fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle.

Some product of other companies like BRAMC etc. giving required resolution and price is reasonable but Accuracy and is not according to requirement.

1080-A Professional is giving required resolution but the measuring principle and accuracy are not mentioned on brochures and supplies have not given

the information, it can also measure the PM 2.5, PM 10, SO_2, NO_2 and O_3, its cost is very high (Rs.37,20,126).

ATS 103M by Applied Techno Systems Ltd.is most suitable option because it is fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle. Its price is also reasonable.

Note: The major problem in comparing different products occur when accuracy is not mentioned in their brochure. Moreover, the measuring principle followed by most companies is not according to the standards. Even if it is as per the standards, the instruments are bigger in size and hence not portable. **This should be relooked.**

Gas chromatography (GC) method is not available in handheld instruments.

3.5.6 SO_2

Most of the products of other companies are giving Electrochemical Sensor which is not according to preferred measuring principle. Most of the products of other companies like Gray Wolf, Uniphos etc. are not fulfilling accuracy, resolution requirement and it is not according to preferred measuring principle.

1080-A Professional is giving required resolution but the measuring principle and accuracy are not mention on brochures and supplies have not the information, it can also measure the PM2.5, PM10, CH_2O, NO_2, and O_3, its cost is very high (Rs.37,20,126).

ATS 103M by Applied Techno Systems Ltd. is a most suitable option because it is fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle. Its price is also reasonable.

Note: Most of the products do not fulfill our criteria for accuracy and resolution. Moreover, the measuring principle followed by most companies is not according to the standards. Even if it is as per the standards, the instruments are bigger in size and hence not portable. **This needs to be relooked.**

3.5.7 NO_2

Most of the products of other companies are giving Electrochemical Sensor which is not according to the preferred measuring principle.

Most of the products of companies like Gray Wolf, Uniphos etc. are not fulfilling accuracy, resolution requirement and it is not according to preferred measuring principle.

1080-A Professional is giving required resolution but the measuring principle and accuracy are not mention on brochures and supplies have not the information, it can also measure the PM2.5, PM10, CH_2O, NO_2, and O_3, its cost is very high (Rs.37,20,126).

ATS 103M by Applied Techno Systems Ltd. is most suitable option because it is fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle. Its price is also reasonable.

Note: Most of the products do not fulfill our criteria for accuracy and resolution. Moreover, the measuring principle followed by most companies is not according to the standards. Even if it is as per the standards, the instruments are bigger in size and hence not portable. **This needs to be relooked.**

3.5.8 O_3

Most of the products of other companies are giving Electrochemical Sensor which is not according to preferred measuring principle.

Most of the products companies like Gray Wolf, Uniphos etc. are not fulfilling accuracy, resolution requirement and it is not according to preferred measuring principle.

1080-A Professional is giving required resolution but the measuring principle and accuracy are not mentioned on brochures and supplies have not the information, it can also measure the PM2.5, PM10, CH_2O, NO_2, and O_3, its cost is very high (Rs.37,20,126).

2B technology ltd.'s Personal Ozone Monitor™ (POM™) is fulfilling accuracy, resolution requirement and it is not according to preferred measuring principle but its price is very high (Rs.3,48,000). Some products of other companies are mentioning the accuracy in terms of %.

ATS 103M by Applied Techno Systems Ltd. is a most suitable option for our project, because it is fulfilling accuracy, resolution requirement but it is not according to preferred measuring principle. Its price is also reasonable.

Note: Most of the products do not fulfill our criteria for accuracy and resolution.

3.5.9 Total Microbial Count

There is no instrument available for on the spot measurement of the microbial count. Samples need to be taken for lab testing. This parameter needs to be relooked under the light of and a number of samples required to being tested and targeted large adaption of IEQ Standard.

3.6 Overall Summary

Considering the equipment availability and difficulty in finding equipment matching requirements specified in ISHRAE IEQ. As interim finding and recommendation, it is required to revisit the specifications mentioned in the standard. Where the threshold value of any parameter such as TVOC and CH_2O is much higher as compared to the least count, the stringency of measurement may be considered.

CHAPTER 4

IEQ ASSESSMENT METHODOLOGY

4.1 Measurement Protocols

Following ISHRAE IEQ Standard, the measurements are carried out once in a month and thrice a day (10:00, 14:00 and 16:30 hrs) to assess all climate changes during different seasons. In thermal comfort measurements, the mean radiant temperature, room air temperature, air velocity and relative humidity are recorded at 0.6 m and 1.1 m for seating and standing positions, respectively. Operative temperatures for the above measurements are calculated to be average of the mean values of mean radiant and room air temperature. IAQ parameters such as concentrations of CO_2, CO, Particulate matter (PM 2.5, PM 10), total volatile organic compounds, formaldehyde, SO_2, NO_2, and O_3 are measured at different occupant locations and also at possible fresh air inlet of the rooms. CO_2 concentration is measured when there is at least 90% occupancy in the building space. In lighting comfort parameters like illuminance, circadian lighting design, uniformity of illuminance and ratio of illuminance of task area to immediately adjacent surroundings are monitored at different potential occupant locations. Illuminance of task area is calculated by taking mean values of illuminance at different points within the task area. The equivalent melanopic lux as the measurement of circadian lighting design is calculated by multiplying the illuminance and melanopic ratio (which relates the correlated colour temperature (CCT) and type of light source). Also, uniformity of illuminance is calculated as the ratio of minimum illuminance to average illuminance of different points within the task area. Further, the acoustic comfort in terms of overall sound level is observed at different locations. Detailed reasons and clarification of measurement protocols are presented in Annexure A.2.

All IEQ measurements done by IITM were carried out for 24 h period for instruments having data logging facility and measurements using instruments that had no data logging option was done thrice a day for two consecutive days. The measurements were done for different seasons; winter (Dec 2017-Feb 2018),

summer (March-June, 2018) and monsoon (July 2018). All the parameters were measured at occupant level and no outdoor measurements were taken. Light measurements were done according to the procedure explained in the above paragraph.

4.2 Site Description

4.2.1 MNIT Jaipur

The assessment has been carried out in Jaipur city (26.9124°N, 75.7873°E) located under composite climate in northern India. The present investigation has been performed at Malaviya National Institute of Technology, Jaipur (IGBC Platinum Rated Green Campus). In the composite climate of Jaipur mainly four seasons are considered. April to June is regarded as summer season, July to August as monsoon season, September as post-monsoon season, November to February as winter season and October and March regarded as moderate season. Two dwellings in the campus have been selected for IEQ investigations. The first building (named as old administration), away from the heavy traffic is situated in an area with rich natural vegetation. While the second one (named as Centre for Energy & Environment (CEEB)) is only 65 m away from the roadway. Both buildings have shared as well as individual offices, classrooms, conference halls and waiting rooms in which some are air-conditioned and others are unconditioned areas.

The third building selected is a residential apartment Building at Jaipur. This building is situated in the highly dense urban area having 3 floors in which only third floor is used for measurement, covers a total area of 125 square meters, 2 Bedrooms, 1 Livingroom and 1 Kitchen and 6 types of potential occupant locations. The detailed descriptions of each building are shown in Table 4.1.

Parameters	Old administration	CEE Building	Residential Building
Area (Sq. Meter)	1400 (distributed over three floors having 25 rooms)	162 (single floor and 3 rooms)	125 (3 floors, 3rd floor used for measurements and 2 Bedrooms, 1 Livingroom and 1 Kitchen)
Construction materials	Stone walls (Ground floor), Brick walls (First and Second floor), RCC roofing	Stone walls, asbestos roofing, acoustic ceiling tiles	Brick walls, RCC roofing
Orientation	South-East, North-West	South-East, North-West	South-East, North-West
Building age	39 Years	40 Years	3 Years
Purpose/uses	Multiuse	Multiuse	Residential
Ventilation type	Mixed mode	Mixed mode	Mixed mode
Occupancy	50 and variable	13	10 and variable
Potential occupant Locations	66	10	6

Table 4.1 Building description in Jaipur

Further, the pictorial views and geographical locations of CEEB and OAB are shown in Figure 4.1

(a)

(b)

Figure 4.1 (a) Geographical view (b) Pictorial view of CEEB and OAB in Jaipur.

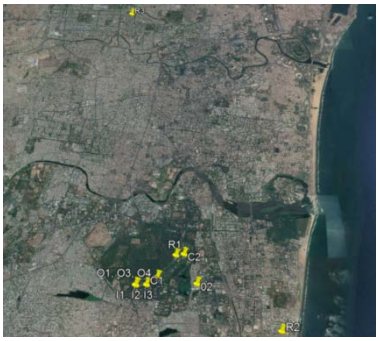
4.2.2 IITM Chennai

The IEQ measurements were carried out in Chennai metropolitan area located at 13.067439°N and 80.237617°E along the south-eastern coastline of Indian continent. The region experiences a tropical climate zone. Most parts of the investigation was carried out within Indian Institute of Technology, Madras campus which is a lush green area located in the heart of Chennai city. All the buildings located inside IITM campus was away from road traffic. In order to compare the effect of outdoor traffic on IEQ, few locations outside the campus located near light to heavy traffic areas were also selected. The sampling locations I1 and I2 was newly built building and during the summer season, construction work was progressing which might have an impact on the measurement values. The detailed descriptions of each building, its location, major activities and other relevant information are given in Table 4.2 below.

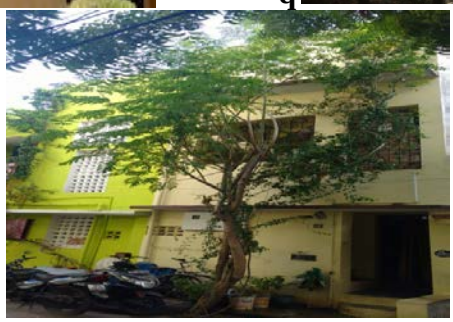
Type of Building	**Location**	**Activities**	**Ventilation**	**Occupants**	**Age of building (years)**	**Area (m^2)**
Computational room (C1)	IITM campus	Occupant movement sweeping, cleaning	AC	50	26	165
Departmental Stores (C2)	IITM Campus	Movement of customers, sweeping, cleaning	Mixed	8	8	55

Type of Building	Location	Activities	Ventilation	Occupants	Age of building (years)	Area (m^2)
Research Scholar room (I1,I2)	IITM campus	Newly built-construction	NV till may and then AC	30	<1	71.1
Laboratory (I3)	IITM campus	Soldering, occupant movement, sweeping	Mixed	5	<1	17.36
Office (O1)	IITM Campus	Occupant movement sweeping, cleaning	AC	10	12	69.3
Office (O2)	Taramani - light traffic		AC	35	2	175.3
Conference hall (O3, O4)	IITM campus		AC	40	12	65.43, 76.3
Residence (R1)	IITM Campus	cooking, sweeping, cleaning	Mixed	3	15	32.51
Residence (R2)	Thiruvanmiyur <1km away from heavy traffic	cooking, sweeping, cleaning	NV	5	20	40.87
Residence (R3)	Anna Nagar <1km away from heavy traffic	sweeping, cleaning	Mixed	3	20	173.35

Table 4.2 Building description in Chennai



(a)



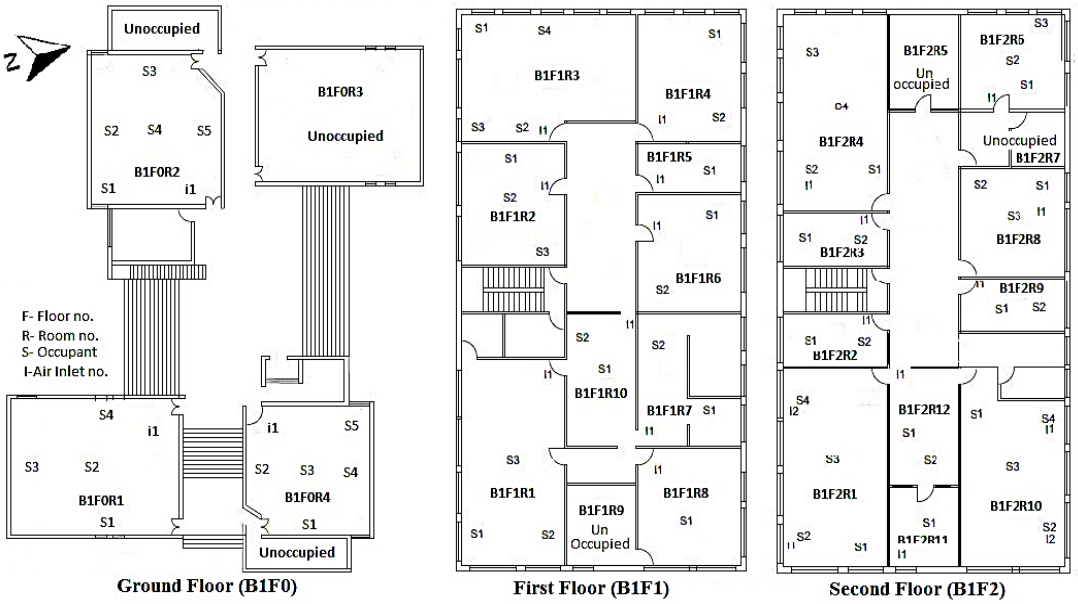
(b)

Figure 4.2 (a) Geographical view (b) Pictorial view of various buildings selected in Chennai

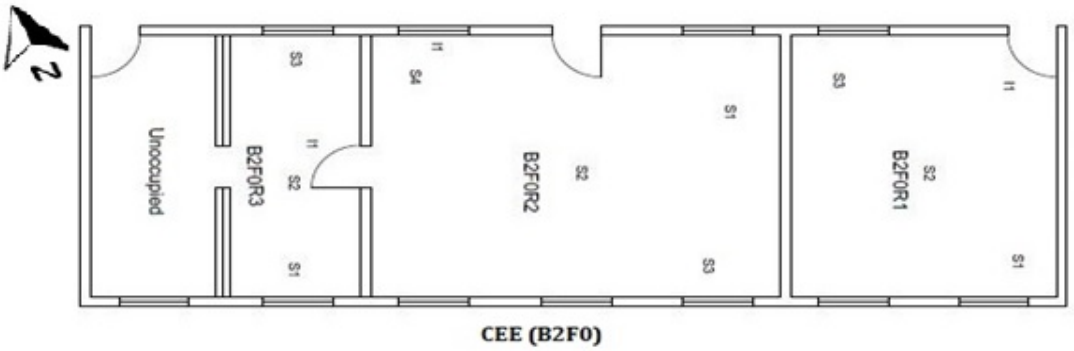
4.3 Measurement Location Selection

4.3.1 MNIT Jaipur

Potential occupant locations are selected for specific positions such as centre of the room, near to window (open/close), away from ventilation, near to the artificial light source, under ceiling fan and air conditioning unit. Detailed reasons for building selection are presented in Annexure A.3.



(a)



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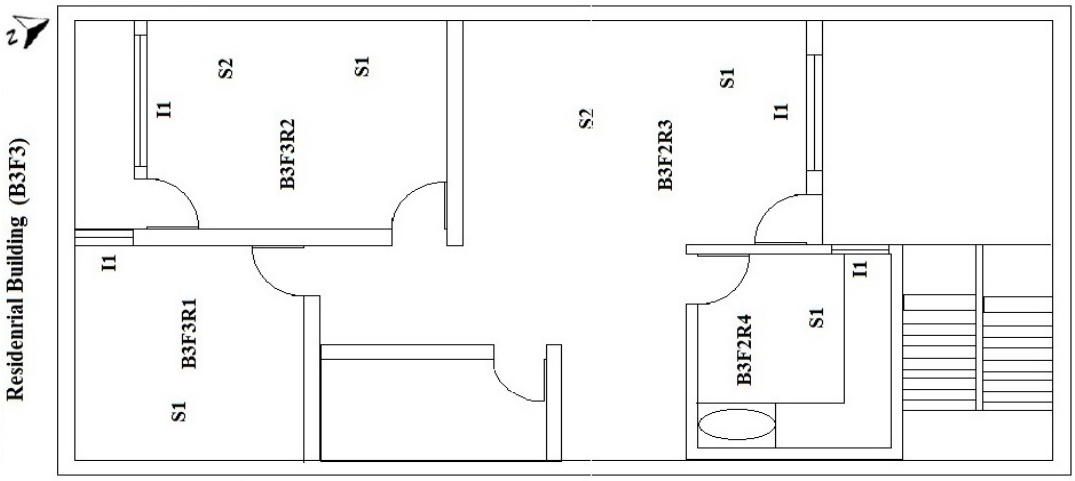


(c)

Figure 4.3 Floor plan and potential occupant location (a) Old administration (b) CEE building (c) Residential Building.

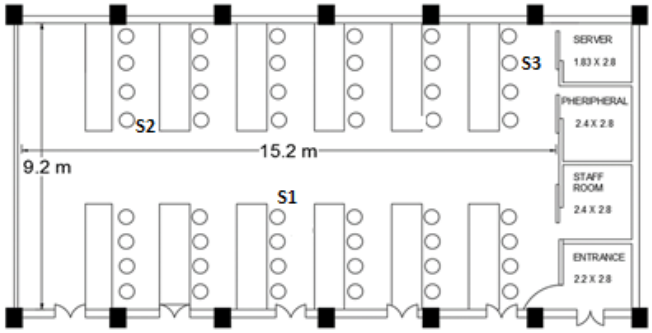
Further, the nomenclatures used for defining different measurement locations are tabulated in Table 4.3

Place	**Code**	**Examples**
Building	B	B1, B2, B3 etc.
Floor	F	F0 for ground floor, F1 for first floor, F2 second floor
Room	R	R1, R2, R3 etc.
Occupant location	S	S1, S2, S3, S4 etc.
Air inlet	I	I1, I2, I3, I4 etc.

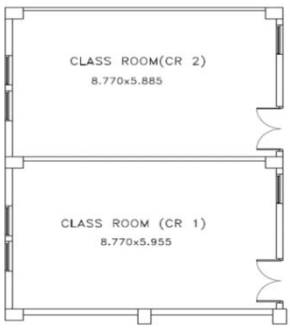
Table 4.3 Nomenclature used for measuring location, Jaipur

4.3.2 IITM Chennai

The floor plan of the buildings included in IEQ measurement campaign conducted at Chennai by IITM is given below.



(a)



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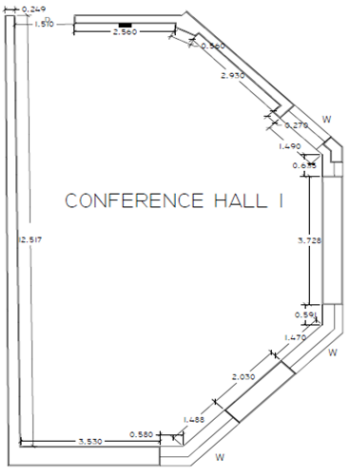
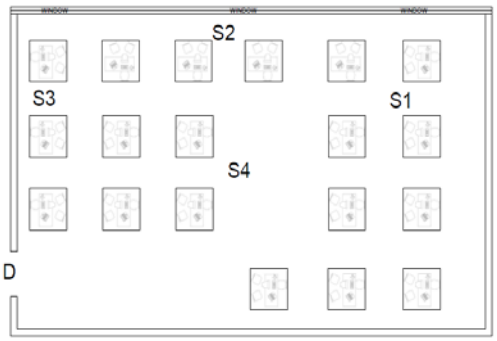


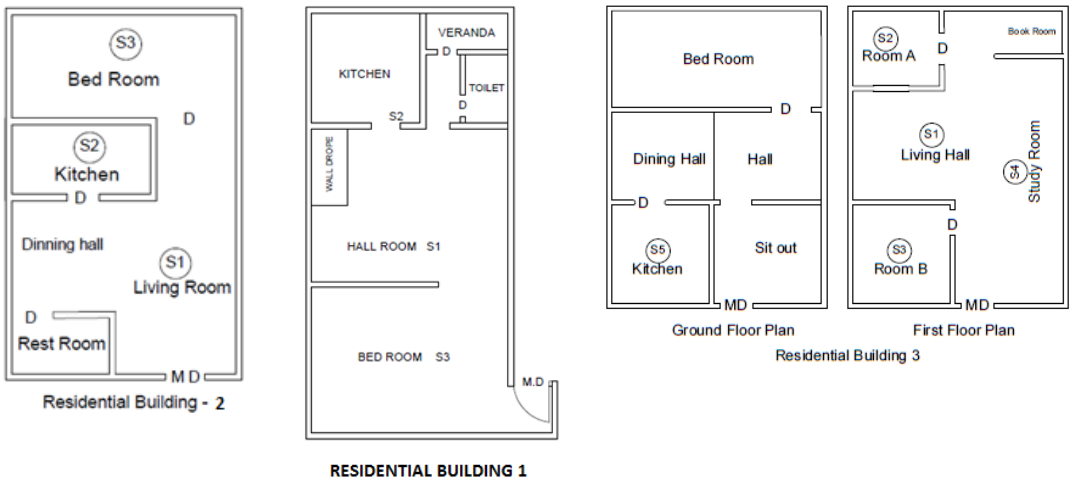
(c)

(d)

(e)



(f)



(g) (h) (i)

Figure 4.4 Floor plan showing sampling occupant location of a) C1; b) I1, I2; c) O3; d) O4; e) O1; f) O2; g) R1; h) R2 and i) R3

The nomenclatures used for defining different measurement locations are tabulated in Table 4.3

Place	**Code**	**Examples**
Commercial building	C	C1, C2, C3 etc.
Office building	O	O1, O2, O3 etc.
Residential building	R	R1,R2,R3 etc.
Institutional building	I	I1,I2,I3,I4 etc.
Sampling points	S	S1,S2,S3,S4 etc.
Floor	F	F1, F2, F3 etc.

Table 4.4 Nomenclature used for measuring location, Chennai

4.4 Instruments

ISHRAE IEQ recommended various instruments to be used for the measurements of different IEQ parameters. The instruments are procured from the standard manufacturers and the details of the instruments used by MNIT and IITM are given in Table 4.3 and Table 4.4 respectively.

Instrument name and model	Manufacturer Name	Parameter	Resolution	Accuracy	Measurement Methodology/Sensor Type
Thermal comfort analyzer (Testo-480)	Testo SE & Company	Air Temperature	0.1 °C	± 0.5 °C	
		Mean Radiant temperature	0.1 °C	± 0.5 °C	
		Relative Humidity	1%	± 3%	
		Air Velocity	0.01 m/s	± 0.05 m/s	
		CO_2	1 ppm	± 5%	NDIR
		Illuminance	1 Lux	± 5%	
Surface thermometer (Testo 905-T2)	Testo SE & Company	Floor Surface Temperature	0.5 °C	± 1 °C	Penetration thermometer
Portable Gas Monitor (ATS-101 M)	Applied Techno Systems Ltd.	TVOC	0.001 ppm (2.29 µg/m3 equivalent to isobutylene)	± 0.005 ppm (11.5 µg/m3	Photo-Ionization Detector (PID)
Portable Gas Monitor (ATS-101 M)	Applied Techno Systems Ltd.	O_3	0.001 ppm (2.0 µg/m3)	± 0.005 ppm (10 µg/m3)	Electro-chemical Sensor
Multi-Gas Monitor Detector (ATS-101 M)	Applied Techno Systems Ltd.	CH_2O	± 0.005 ppm (6.14 µg/m3)	0.001 ppm(1.23 µg/m3)	Electro-chemical Sensor
		SO_2	± 0.005 ppm (13 µg/m3)	0.001 ppm (2.6 µg/m3)	Electro-chemical Sensor
		NO_2	± 0.005 ppm (10 µg/m3)	0.001 ppm (1.9 µg/m3)	Electro-chemical Sensor
		CO	0.01 ppm	± 5%	Electro-chemical Sensor
Air Quality Monitor	Applied Techno System Ltd.	$PM_{2.5}$	1 µg/m^3	± 5%	Light Scattering
(Y09-PM)		PM_{10}	1 µg/m^3	± 5%	Light Scattering
Sound level meter (Lutron SL-4010)	Lutron Electronic Enterprise Co. Ltd.	Sound	1 dB	± 1%	Microphone

Table 4.5 Specifications of instrument used by MNIT

Instrument Name	Instrument Make	Instrument Model	Parameters	Resolution	Accuracy	Measurement Methodology/Sensor Type
Air Quality Monitor	Applied Techno Systems	Y09-PM	$PM_{2.5}$	1 µg/m3	5%	Light Scattering
			PM_{10}	1 µg/m3	5%	Light Scattering
Phocheck Tiger	Ion Science		TVOC	0.001 ppm (2.29 µg/m3 equivalent to isobutylene)	± 0.005 ppm (11.5 µg/m3)	Photo-Ionization Detector (PID)
Portable Gas Monitor	Applied Techno Systems	ATS-101 M	O_3	0.001 ppm (2.0 µg/m3)	± 0.005 ppm (10 µg/m3)	Electro-chemical Sensor
Multi-Gas Detector	Applied Techno Systems	ATS-103 M	CH_2O	± 0.005 ppm (6.14 µg/m3)	0.001 ppm(1.23 µg/m3)	Electro-chemical Sensor
			SO_2	± 0.005 ppm (13 µg/m3)	0.001 ppm (2.6 µg/m3)	Electro-chemical Sensor
			NO_2	± 0.005 ppm (10 µg/m3)	0.001 ppm (1.9 µg/m3)	Electro-chemical Sensor
Thermal Environment meter	Delta Ohm Srl	HD32.3	Ta, RH, Tr, Va	0.1°C	±0.5°C	Ta Thinfilm Pt100
				0.1%	±2.5%	RH Capacitive Sensor
				0.1°C	±0.5°C	Tr Pt100
				0.01m/s	±0.05m/s	Va Probe with Omnidirectional Hotwire (NTC 10Kohm)
Indoor air quality meter	TSI	IAQ CALC 7545	CO, CO_2, Ta, RH	0.1°C	±0.6°C	T: Thermistor
				0.1%	±3%	RH: Thin film capacitive type
				0.1ppm	±3%	CO: Electrochemical
				1ppm	±3%	CO2: NDIR
Noise level meter	Envirotech	SLM 100	SPL	1 dB	±5%	Microphone
Lux meter	Work Zone	LX101	Light intensity	1 Lux	±5%	Light sensor
Surface temperature	Testo	905-T2	Ts	0.1°C	±1%	Penetration thermometer
Bio sampler	Merck	MAS100	TBC	-	-	Impaction

Table 4.6 Details of the instrumentation used by IITM

4.5 Occupant Response and Sample Size

Subjective method is used to record the responses from occupants using a 7-point subjective scale for the given environment as specified in the ISHARE IEQ standard. Questionnaire is designed to record the various effects (sensation, comfort, preference, annoyance, stiffness, and smell) to perform subjective assessment of occupant comfort. Qualitative impact of parameters such as room temperature, RH, air flow, stale air, overall lighting, external view and daylight availability are recorded in the questionnaire. The questionnaire is developed in such a way that all the responses can be recorded with easiness using a 7-point scale. Where it represents 1 as the worst unsatisfactory response and 7 as the best satisfactory response. Each parameter is represented in term of % satisfaction, where the response 1, 2 and 3 as unsatisfactory response and 4, 5, 6 and 7 as satisfactory response. Further, many other parameters such as gender, weight, age, height and native place representing occupant anonymity are also recorded in the same questionnaire, as suggested by (Dhaka et al., 2013). The total responses collected through the occupants are 2790 (2466 M + 324 F) for the month of June 2017 to May 2018. The average weight, age, height and body surface area of occupants are observed to be 59.94 Kg, 24 years, 1.61 m and 1.62 m^2, respectively.

The same procedure for subjective measurement was carried out by both MNIT and IITM. Whereas in Chennai the total number of questionnaire collected was 1100 (752 M + 348 F) during the period from December 2017 to July 2018.

The requirement of a standardized data collection form was felt during the initial days of measurement. The same has been developed and used for subsequent readings. The same is placed at Annexure A.4.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

Various surveys and measurements are conducted during the months of June 2017 to Jan 2018 enabling us to assess the indoor environmental quality of mixed mode buildings located in the composite climate of Jaipur. Thus, the data obtained is used to calculate the various parameters of IEQ elements and the same are presented in this section. Detail IEQ measurement results for 12 months are placed at Annexure A.5

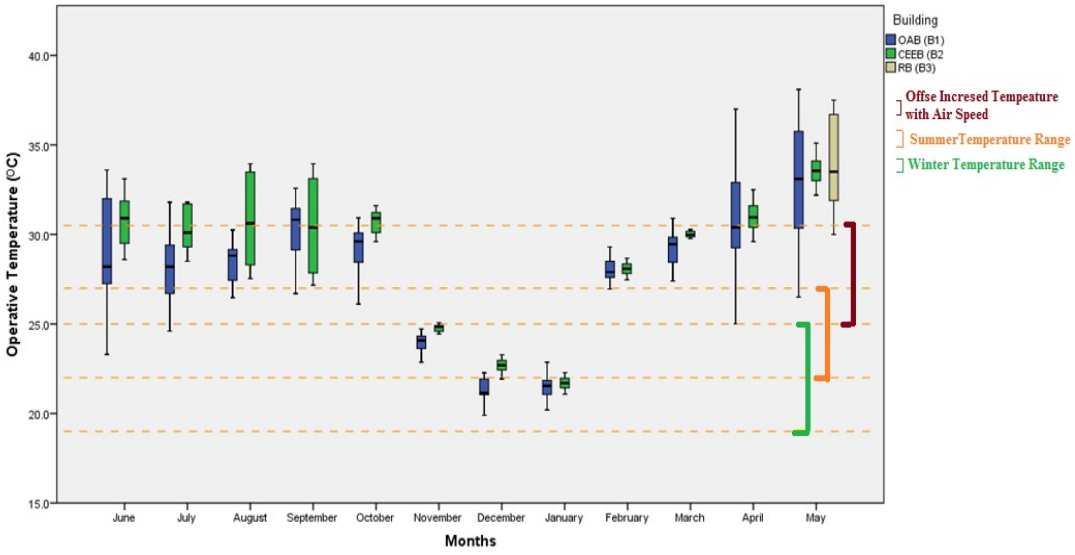
5.2 Thermal comfort

5.2.1 Introduction

In this section, several parameters of thermal comfort such as operative temperature, air velocity, relative humidity and floor surface temperature are measured at different potential occupant locations.

5.2.2 Operative Temperature and Air Velocity

Since operative temperature represents the combined effects of room air temperature, mean radiant temperature and air velocity recorded for the specified potential occupant location. It measures the effects of radiation and convection heat transfers in the actual non-uniform indoor climate. In general, the operative temperature can be obtained as the average value of room air temperature and mean radiant temperature for occupants involved in sedentary physical activity ($1.0 < met < 1.3$) provided the occupant is not exposed to direct sunlight and higher air velocities (> 0.2 m/s). For air velocity up to 0.2 m/s, the acceptable range of operative temperature is given in ISHRAE IEQ standard (10001:2016). For higher air velocities attributed towards an increase in comfort temperature, the required acceptable range can be obtained by using approach given in ISO 7730.



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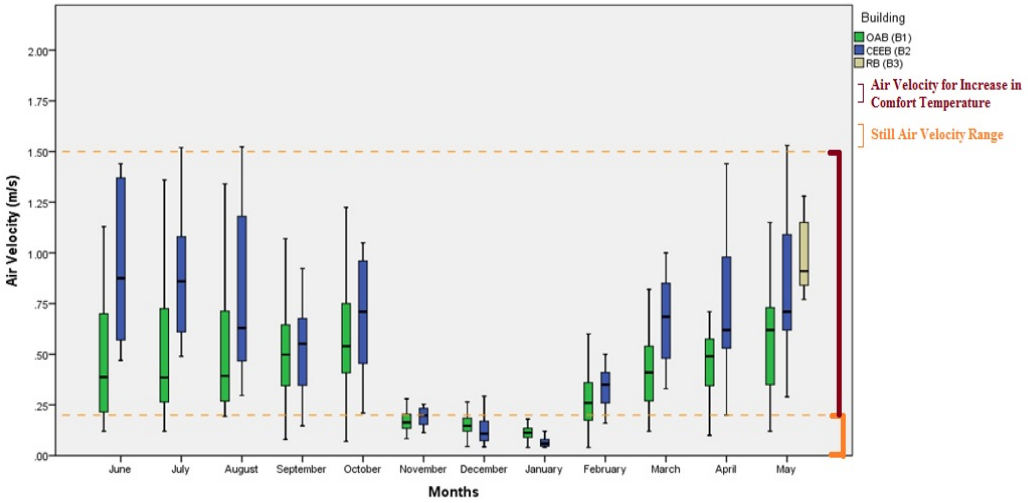
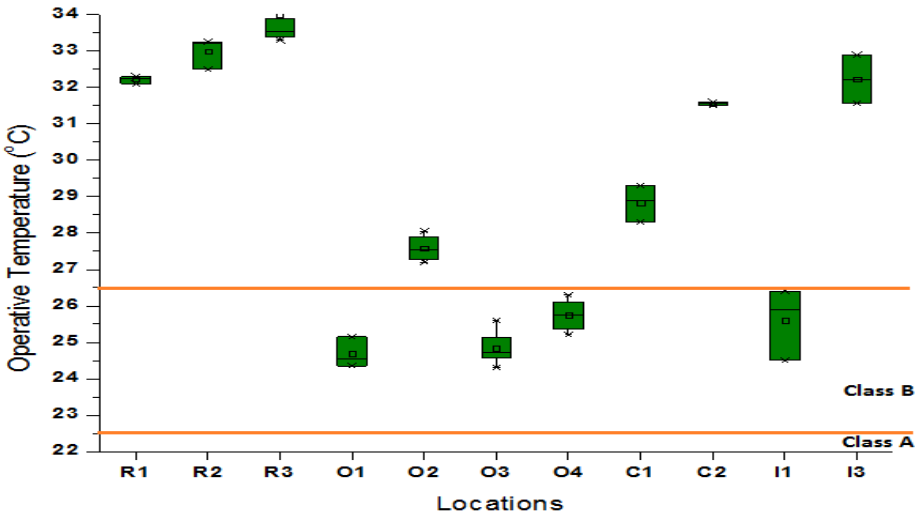


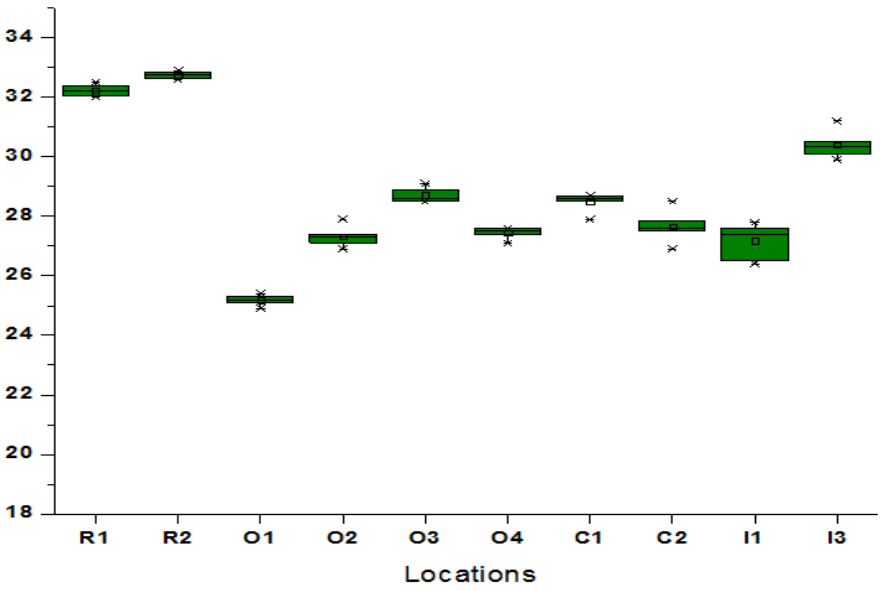
(b)

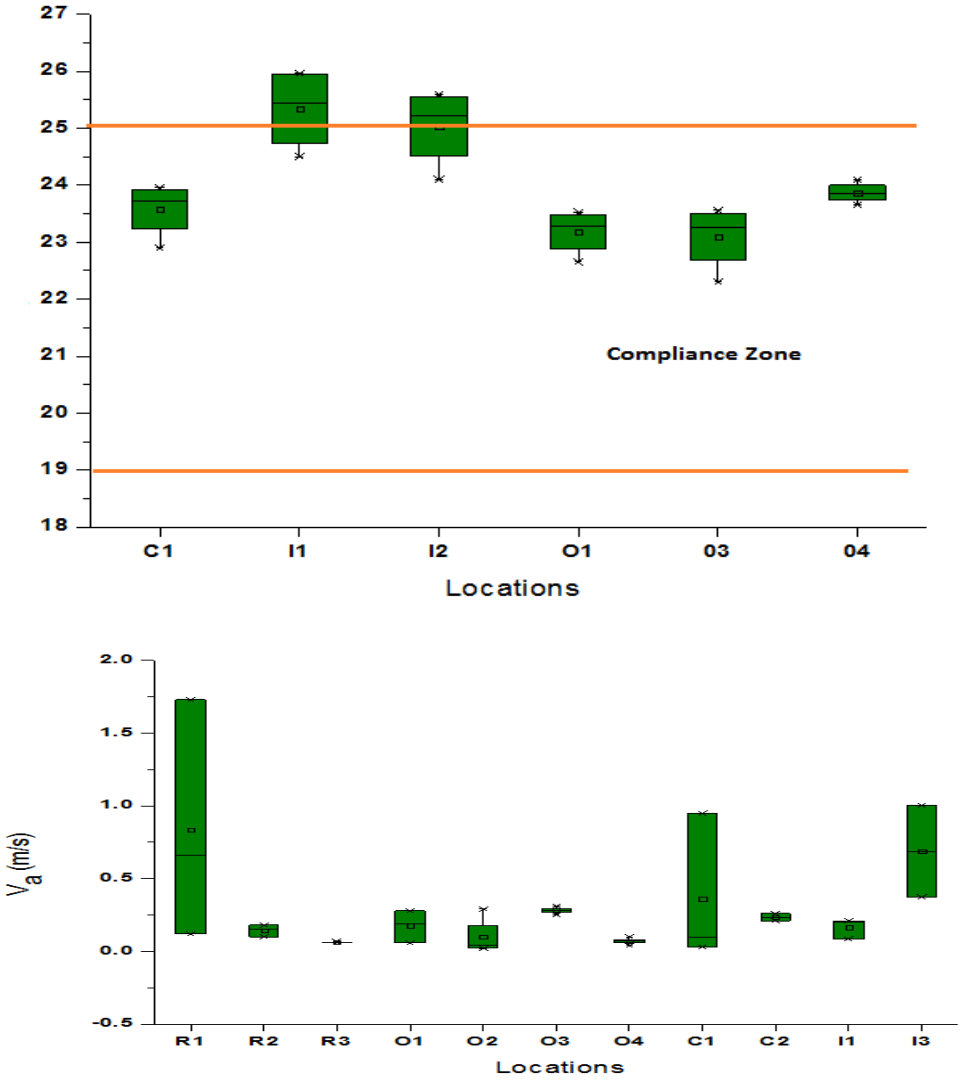
Figure 5.1 Monthly variations in (a) operative temperature and (b) air velocity in Jaipur

The mean operative temperature and ambient temperature are found to be maximum for the month of May during the summer season. Due to pre-monsoon effects, the ambient temperature in June month was observed to be bit lower. However, the variation of operative temperature (difference b/w maximum and minimum) during summer is more as compared to the remaining seasons because of minimum operative temperature is calculated against air-conditioned space while the maximum operative temperature is determined for naturally ventilated space. Indoor operative temperature is directly related ambient temperature. The potential

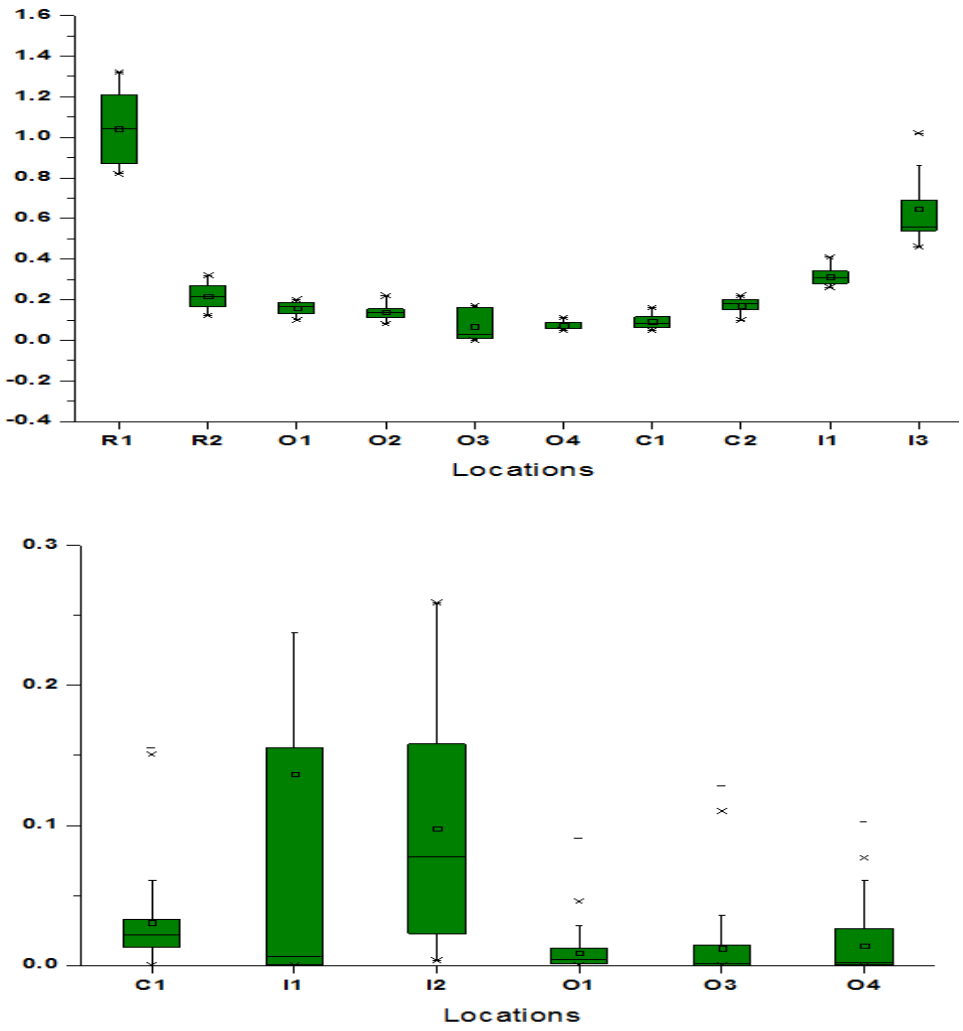
occupant locations (for both air-conditioned and naturally ventilated space) complying acceptable operative temperature during summer, monsoon, post monsoon, winter, and moderate are found to be 31 %, 62 %, 65 %, 99% and 91 % respectively. However, due to high air velocity, some of the potential occupant locations are found in an acceptable range even at a higher operative temperature (up to 30.5°C) in naturally ventilated space during summer, monsoon and post-monsoon seasons.






27
26
25
24
23
22
21
20
19
18
Compliance Zone
C1
I1
I2
O1
03
04
Locations
2.0
1.5
1.0
0.5
0.0
-0.5
V_a (m/s)
R1
R2
R3
O1
O2
O3
O4
C1
C2
I1
I3
Locations

(a)



(b)

Figure 5.2 Location wise variations in (a) operative temperature and (b) air velocity for summer, monsoon and winter seasons respectively in Chennai

The operative temperature was found to be highest for summer season with 64% of sampling locations lying outside the compliance zone. In winter season, 67% of the sampling locations had operative temperature within the threshold limits. It was seen that operative temperature in air conditioned buildings where there is occupant control over the room temperature were within the comfort range. It was noticed that higher air velocity at some locations were found to have lower operative temperature.

5.2.3 Relative Humidity

Relative humidity plays vital role in the assessment of thermal comfort for the given built environment. Since Jaipur is having composite climate where relative humidity varies substantially across the year and observed to be summer (32%), monsoon (59%), post-monsoon (44%), winter (34%) and moderate season (28%). The maximum monthly average value (72 %) of RH is observed for the month of July while the minimum monthly average value (22%) of the same is found for the month of November. However, the maximum variation in RH values is recorded for the month of August. This trend of variation in RH values can be due to limited or unpredicted rainy spell during the monsoon season. Whereas the minimum variation in RH values is recorded for the month of November due to short winter period having no significant variations in climate. Thus, the majority of data obtained for RH is complying with thermal comfort, as prescribed by ISHARE IEQ Standard. However, the discomfort due to low RH arises because of high temperature conditions around the year. Moreover, the occupant satisfaction level achieved for threshold range of RH is found to be 80%. The potential occupant locations (for both air-conditioned and naturally ventilated space) complying acceptable relative humidity during summer, monsoon, post-monsoon, winter, and moderate season are found to be 55 %, 41 %, 99%,97% and 36 % respectively.

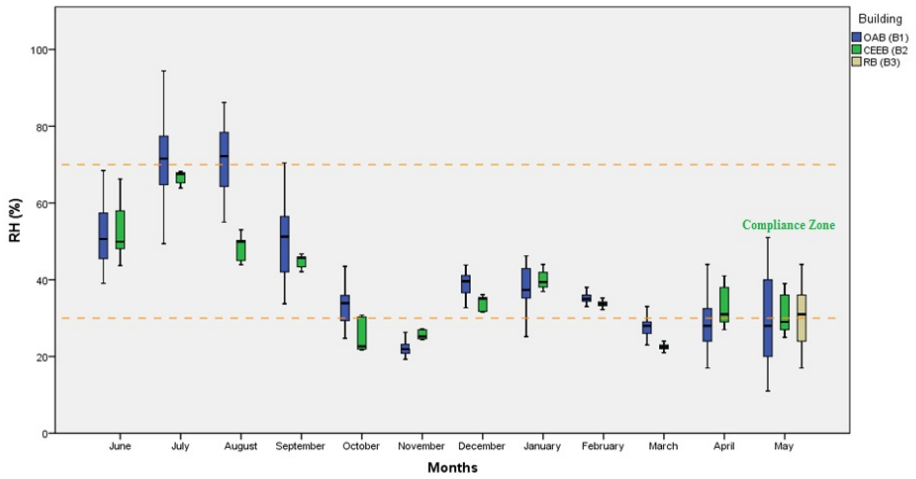
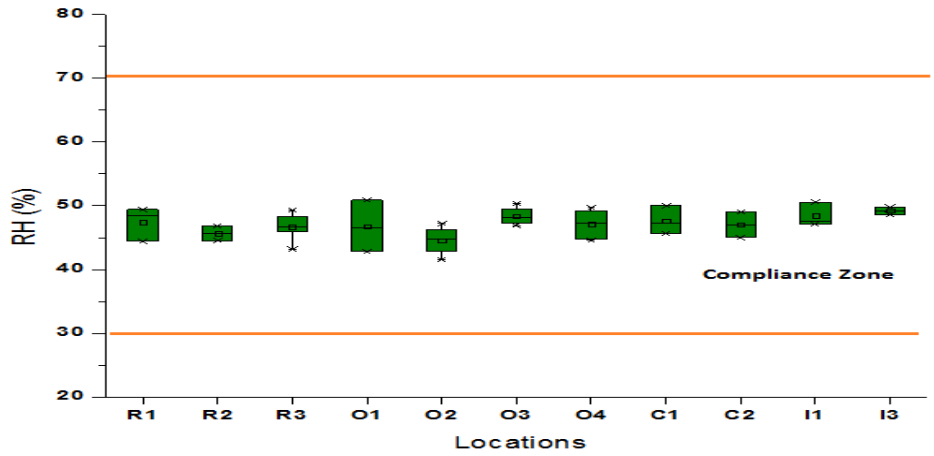
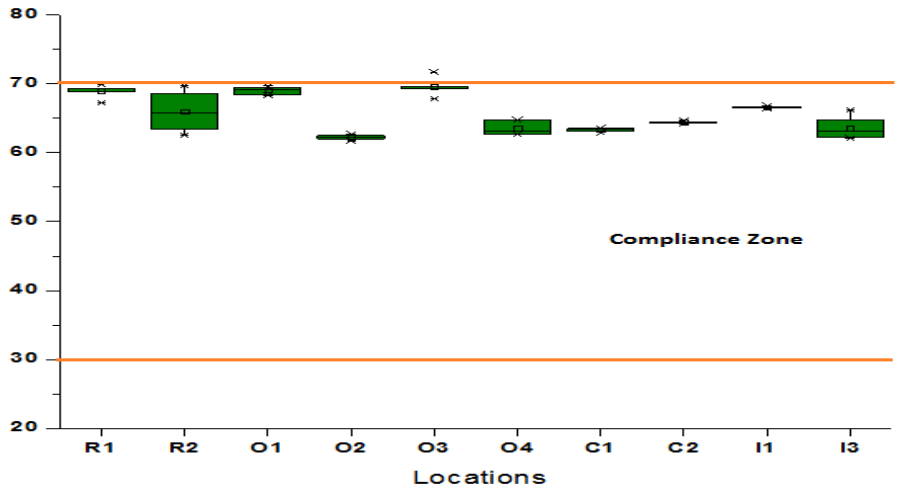


Figure 5.3 Monthly variations in relative humidity in Jaipur





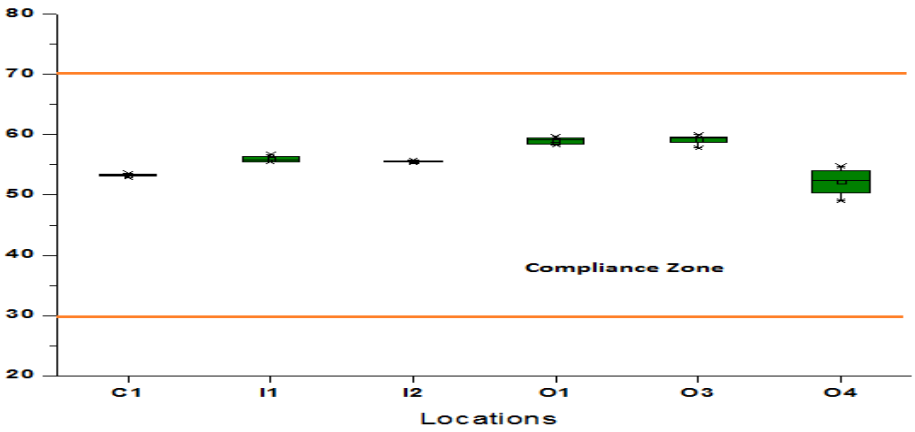


Figure 5.4 Location wise variations in relative humidity for summer, monsoon, and winter respectively in Chennai

The average relative humidity in Chennai for summer, monsoon and winter season are 49%, 66%, and 57% respectively. The average relative humidity in Chennai for summer, monsoon and winter season are 64%, 72%, and 70% respectively with highest in monsoon season and lowest in summer season. All the recorded RH values are within the compliance zone.

5.2.4 Floor Surface Temperature

The temperature of floor surface where the occupant's feet are in contact with is termed as floor surface temperature. The occupant may feel discomfort due to too warm or too cool temperature of floor. Therefore, the material of floor plays an important role particularly for foot thermal comfort while wearing shoes. Local thermal discomfort is a function of various locally specified parameters such as vertical temperature gradient (between feet and head), uniformity of radiant temperature and local convective heat transfer via hot and cold floor surface. Following ISHRAE IEQ standard, the floor surface temperature for the occupants heaving feet contacts with floor shall be 17 – 31ºC within the occupant zone. In the present study, the mean value of floor surface temperature for summer, monsoon, post-monsoon, winter, and moderate seasons are found to be 33.4 ºC, 29.7 ºC, 30.9 ºC, 21.3 ºC and 28.2 ºC respectively. During summer, the floor surface temperature exceeds the comfort limit due to the fact that the ambient temperature in the aforesaid location hits more than 35 ºC. Also, the floor surface temperature is found

to be relatively higher near the wall exposed to direct solar. In the old administrative building, since the floor material of first and second floors are made up of RCC and therefore, attributed to conduct more heat (due to high conductive steel rods) causing higher floor surface temperature as compared to the floor having underneath ground surface.

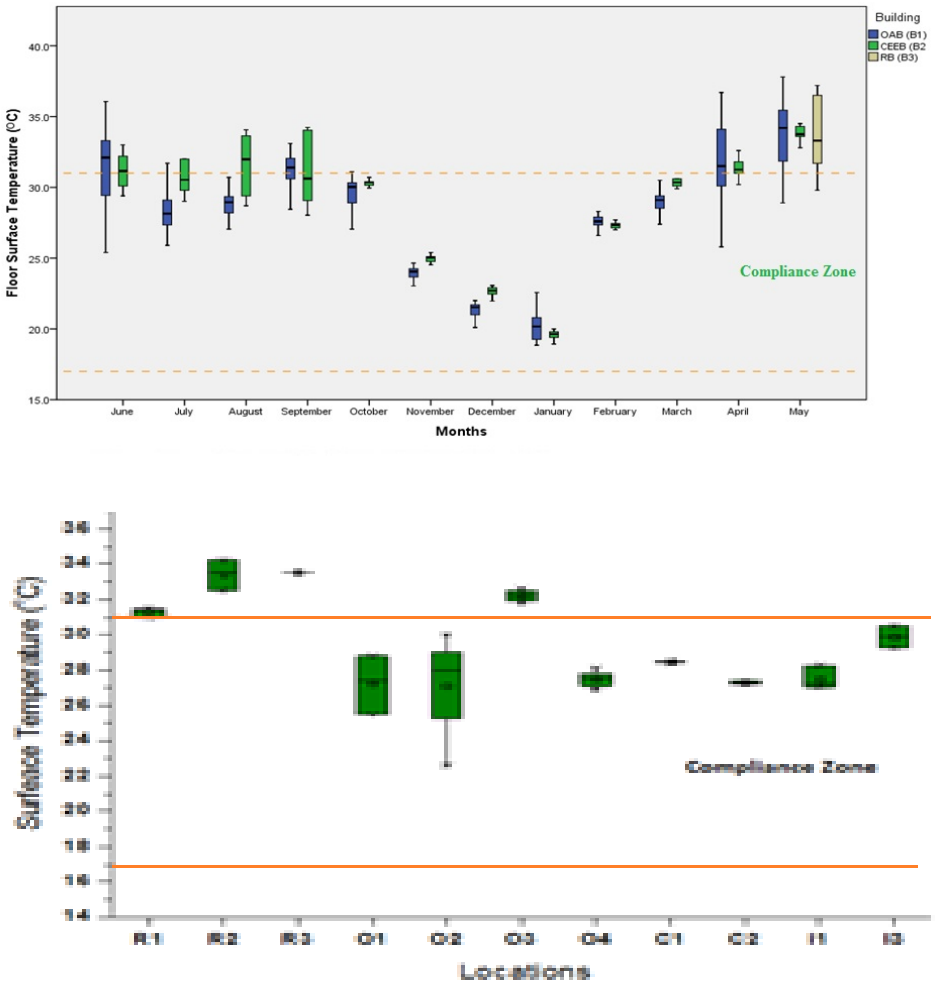


Figure 5.5 Monthly variations in floor surface temperature in Jaipur

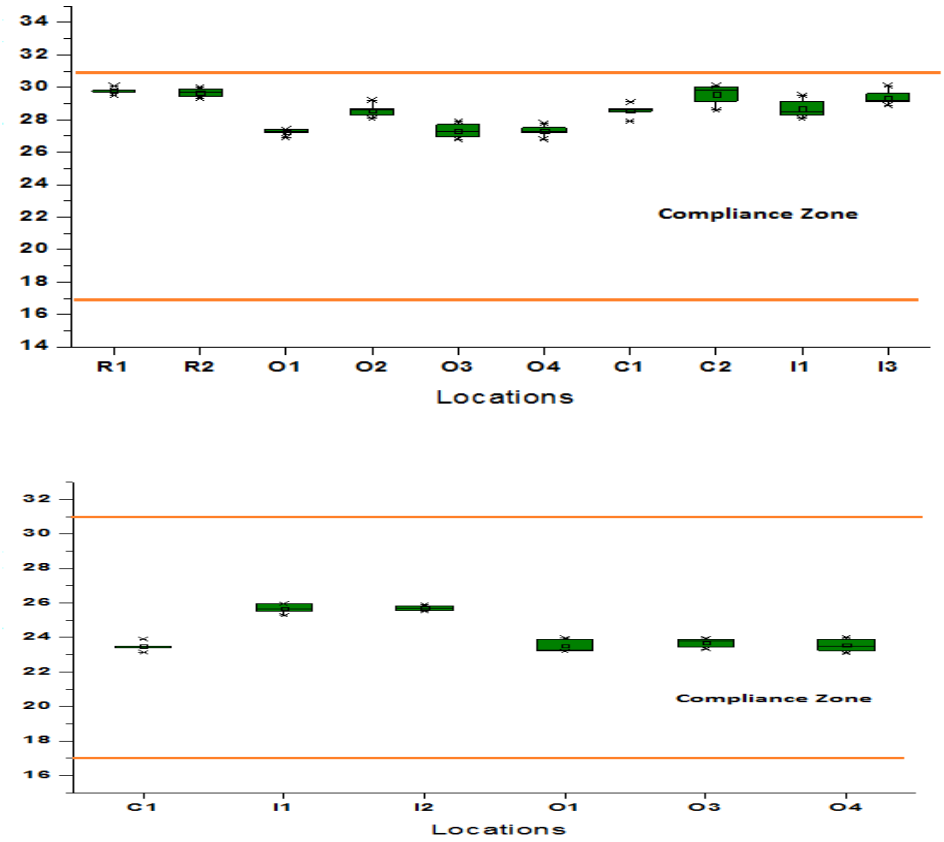


Figure 5.6 Location wise variations in floor surface temperature for summer, monsoon and winter respectively in Chennai

The mean floor surface temperature for summer, monsoon and winter was 29.3°C, 27.4°C and 24.5°C respectively. During summer season, floor surface temperature in 36% of locations fell out of the compliance zone due to higher ambient temperatures reaching 37°C during the day. Floor surface was found to be highest in residential buildings (R2 and R3) which is located in the city centre with less vegetation cover and probably higher outdoor temperature.

5.3 Indoor Air Quality

5.3.1 Introduction

Another important element of IEQ is indoor air quality which specifies the indoor air characteristics in terms of concentrations of CO_2, $PM_{2.5}$, PM_{10}, CH_2O, SO_2, NO_2, O_3, TVOC, CO etc. The details of each have been discussed in this section.

5.3.2 CO_2 Concentration

The concentration of $CO_2$is measured at each potential occupant locations in the room has at least 90% occupancy. Due to high natural vegetation in MNIT campus, the ambient CO_2 concentration is found to be 400± 25 ppm. The monthly variations in CO_2 concentration are illustrated in Figure 5.7. In the present study, the mean value of CO_2 concentrations for summer, monsoon, post-monsoon, winter, and moderate seasons are found to be 534 ppm, 443 ppm, 476 ppm, 512 ppm and 479 ppm respectively. The CO_2 concentration range for all seasons is falling under Class A, as specified by ISHRAE IEQ standard.

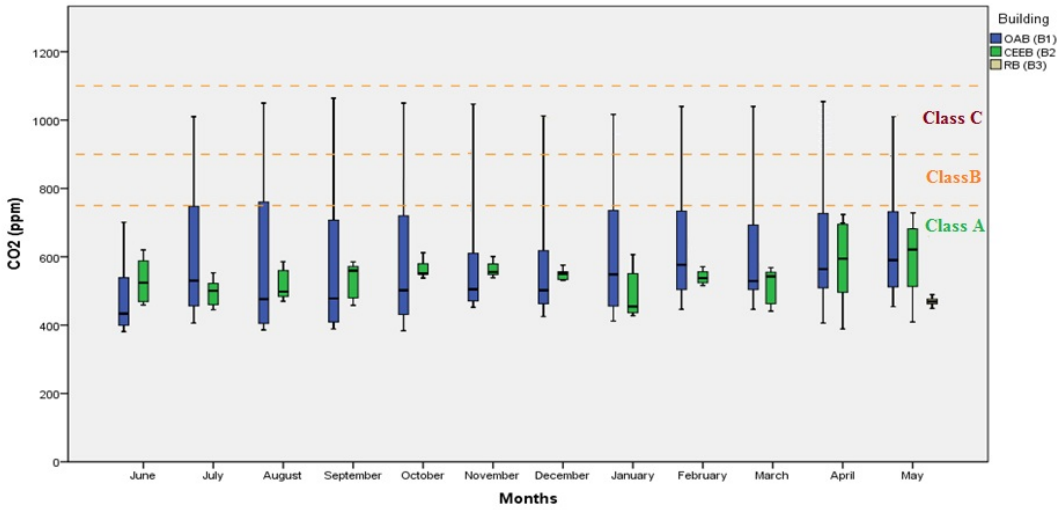


Figure 5.7 Monthly variations in CO_2 concentration in Jaipur

The standard deviation of the seasonal mean of CO_2 concentration is found to be ± 47 ppm which implicates that the effect of different seasons on CO_2 concentration is quite low. The two major elements influencing CO_2 concentration are observed to be the fresh air intake and occupancy. The high concentration is recorded in the classrooms due to high occupancy and the same is found in rooms (conditioned by split air conditioners) due to less availability of fresh air. However, the lower concentrations are recorded in naturally ventilated rooms and evaporative cooler rooms where the fresh air intake is high.

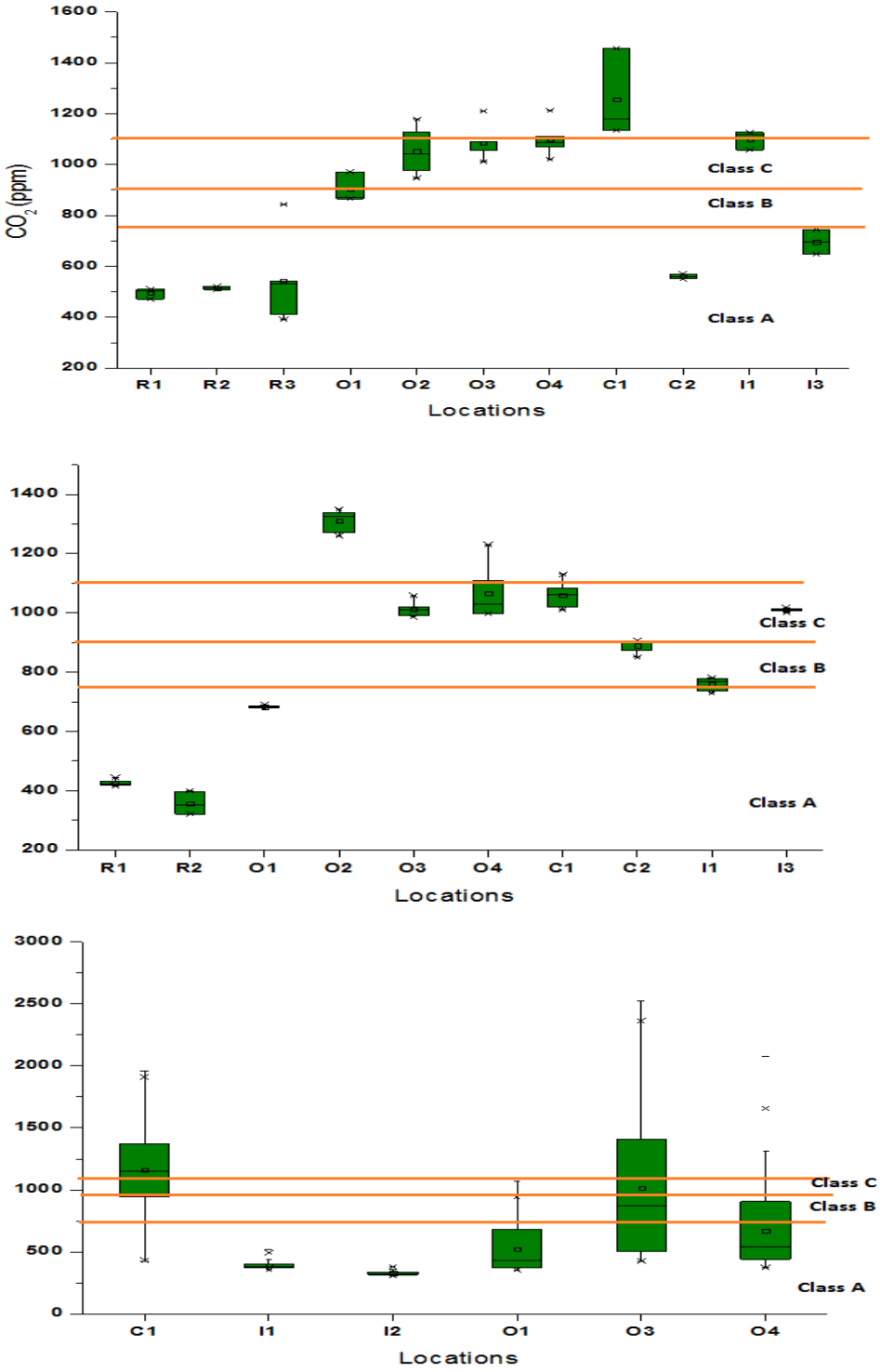
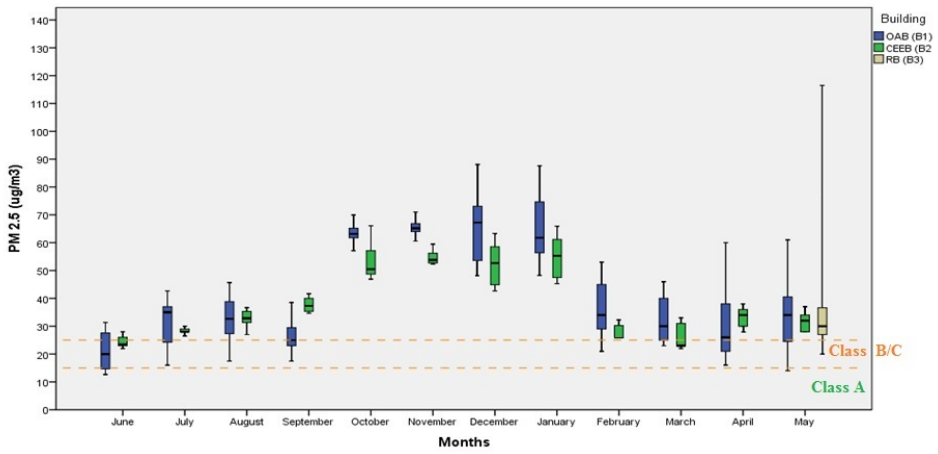


Figure 5.8 Location wise variations in CO_2 for summer, monsoon and winter respectively in Chennai

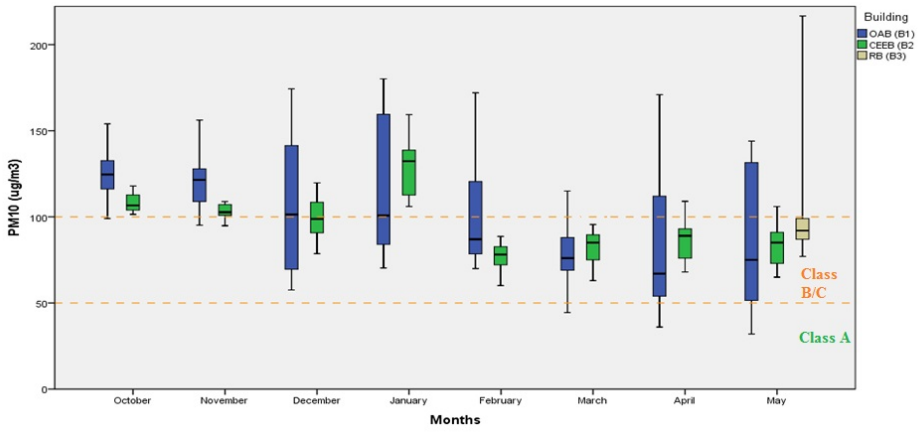
Higher CO_2 concentration was observed in air conditioned institutional buildings and offices. As pointed out previously ventilation and occupancy are two main factors that affect the CO_2 concentration. Lowest CO_2 levels were recorded at residential buildings were number of occupants are less whereas highest CO_2 concentration was noted at air conditioned office building irrespective of the monitoring season.

5.3.3 RSPM Concentration

The presence of particulate matter in environment affects the indoor air quality to large extent and thus it has always been of great interest to the scientific community. The monthly variations in PM2.5 and PM10 concentration are illustrated in Figure 5.9. The mean value of PM2.5 concentrations for summer, monsoon, post-monsoon, winter, and moderate seasons are found to be 33 µg/m^3, 30 µg/m^3, 34 µg/m^3, 61 µg/$m^3$and 44 µg/m^3respectively. Further, the mean value of PM 10 concentration for summer, winter, and moderate seasons are found to be 81 µg/m^3, 121 µg/m^3,123 µg/$m^3$and 97 µg/m^3respectively.



(a)

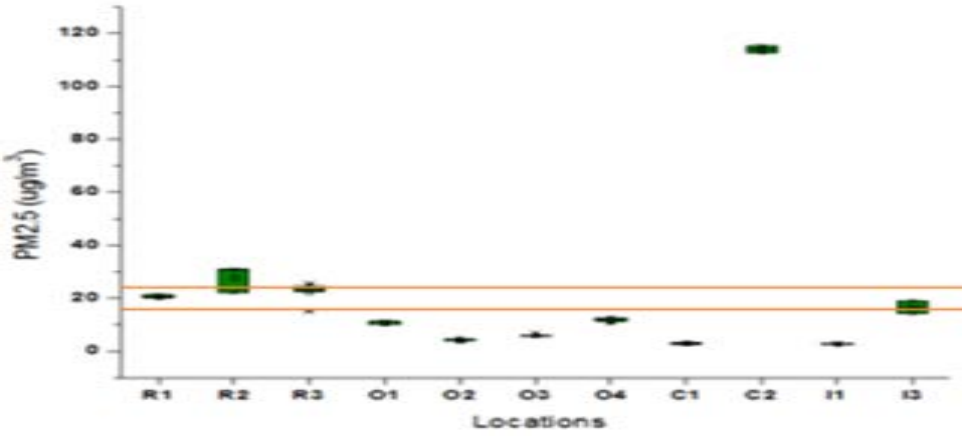


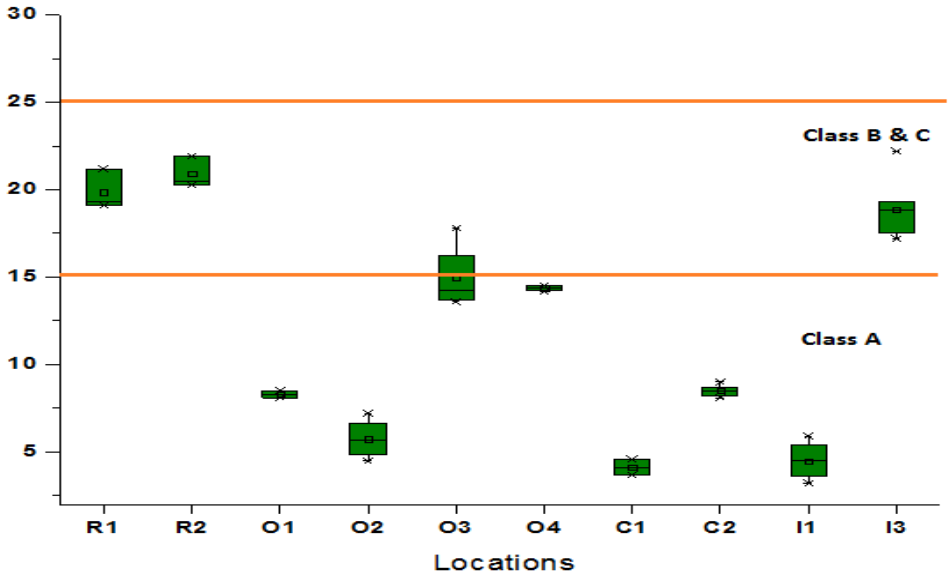
(b)

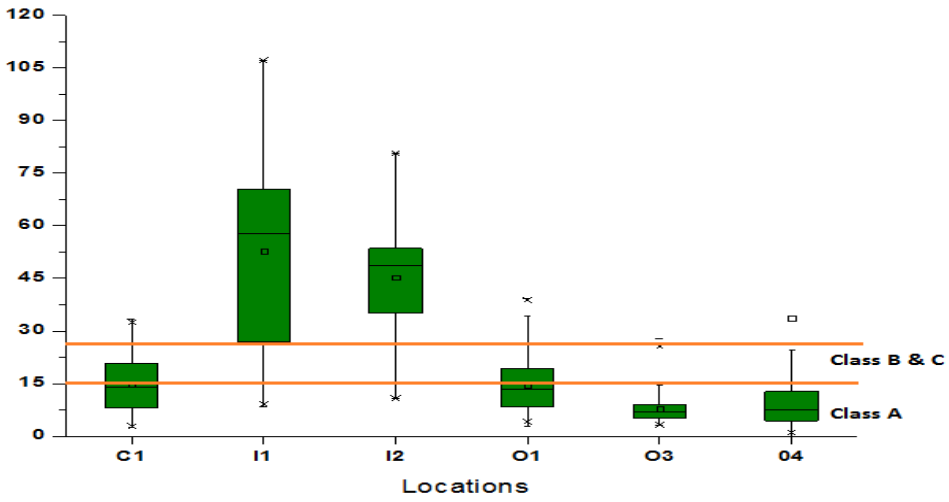
Figure 5.9 Monthly variations in (a) PM 2.5 (b) PM 10 concentration in Jaipur

Mean monthly Concentrations of PM 2.5 is observed to be increased during the month of September (25.3µg/m3) to October (64.5µg/m3). This high increment in the concentrations of PM2.5 is due to the effect of Diwali festival (Celebrated in India) in which a huge amount of busting of firecrackers happens. In monsoon season, the lower concentrations of particulate matters are observed due to the fact of washout of the particles from the atmosphere. In the summer season, lower particulate matter concentrations are observed because of better dispersion due to high temperature and deep height mixing of pollutants. Also, the use of evaporative cooler results in the low particulate matter concentrations because of the fact that the airborne particles presented in the ambient air get stuck with water droplets and deposited at water sump. During winter, the particulate matter concentrations are recorded high due to mainly two reasons i.e. less dispersion caused by lower temperature and restricted vertical air movements caused by pressure differences. Further, the high concentrations of PM have also been found in indoor environment due to various factors such as outdoor air infiltration, room cleaning and re-suspension of airborne particles deposited on the surfaces.

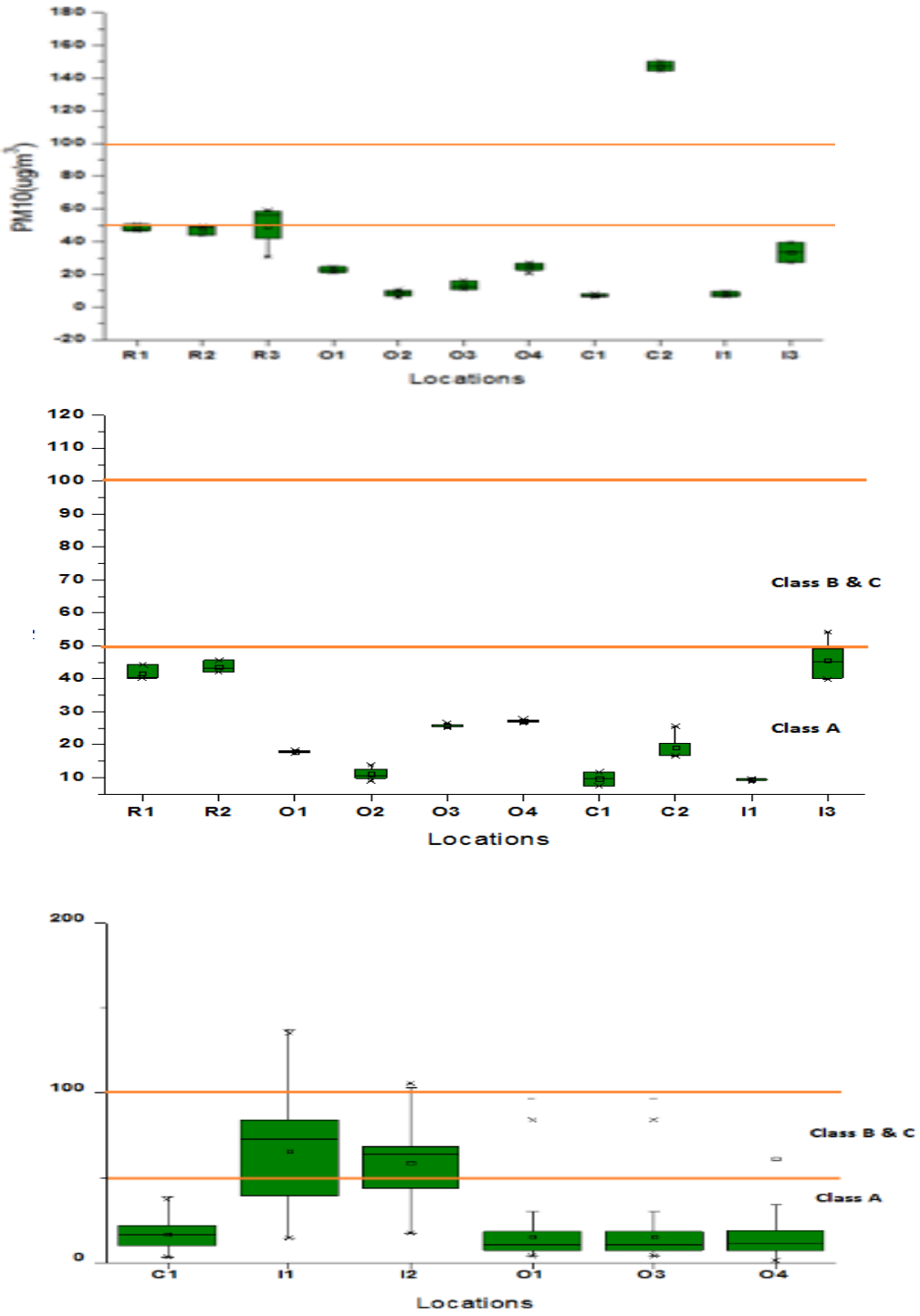
For residential building, the PM concentrations are found to be highest in the kitchen. While cooking without using of exhaust fan, PM 2.5 and PM 10 concentrations are reached at 210 µg/$m^3$and 560 µg/m^3respectively. Further, using of exhaust fan, PM 2.5 and PM 10 concentrations are found to be 84 µg/$m^3$and 226 µg/m^3respectively.


PM2.5 (ug/m³)
120
100
80
60
40
20
0
R1
R2
R3
O1
O2
O3
O4
C1
C2
I1
I3
Locations


30
25
20
15
10
5
Class B & C
Class A
R1
R2
O1
O2
O3
O4
C1
C2
I1
I3
Locations


120
105
90
75
60
45
30
15
0
Class B & C
Class A
C1
I1
I2
O1
O3
04
Locations

(a)



(b)

Figure 5.10 Location wise variations in (a) $PM_{2.5}$ (b) PM_{10} concentration for summer, monsoon and winter season respectively in Chennai

The location wise variation in $PM_{2.5}$ and PM_{10} for different monitoring seasons in Chennai is shown in Figure 5.10. $PM_{2.5}$ and PM_{10} concentration was found to be well within the acceptable range for all air conditioned microenvironment. The mean values of $PM_{2.5}$ and PM_{10} in C2 which is a departmental store was found to 115 µg/m^3 and 150 µg/m^3 respectively. This high concentration may be due to occupant movement, resuspension of dust or cleaning activities which took place at the site. The $PM_{2.5}$ concentrations in residential buildings was found to be above acceptable limit of 25 µg/m^3, which may be due to cooking activities whereas the PM10 concentration was found to be within the acceptable limits. The PM concentration in I1 and I2 was above the acceptable limits in winter season because of the construction activities that took place during that time period.

5.3.4 TVOC and CH_2O Concentrations

Sum of the concentration of identified and unidentified volatile organic compounds eluting between and including n-hexane and n-hexadecane is termed as Total Volatile Organic. Formaldehyde is a colorless gas with a pungent odour and highly reactive. In the present study, TVOC and CH_2O concentration are measured for four months (February 2018 to May 2018). The monthly variations in TVOC and CH_2O concentrations are presented in Figure 5.11.

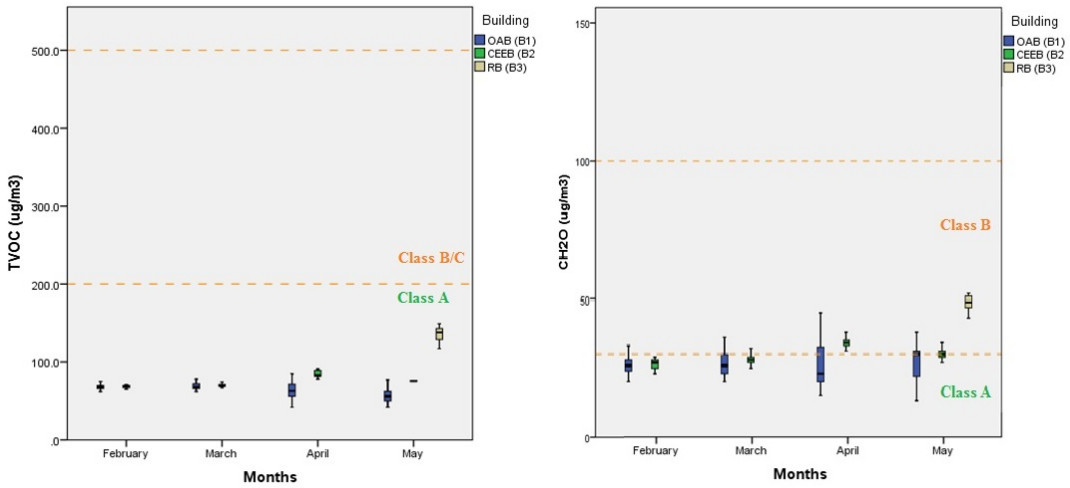
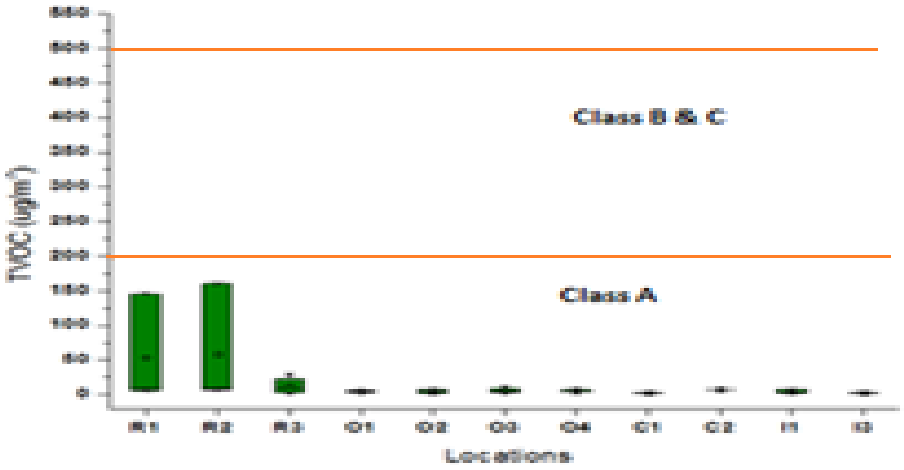
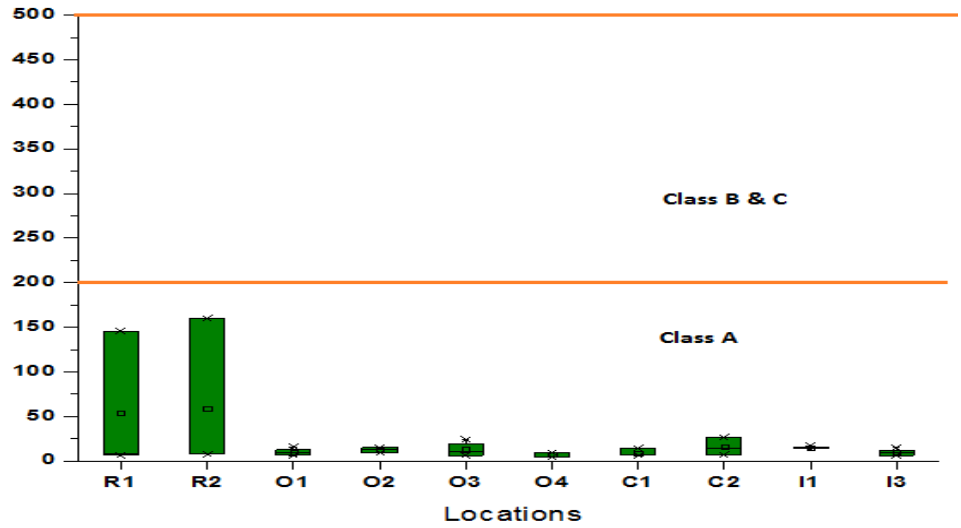
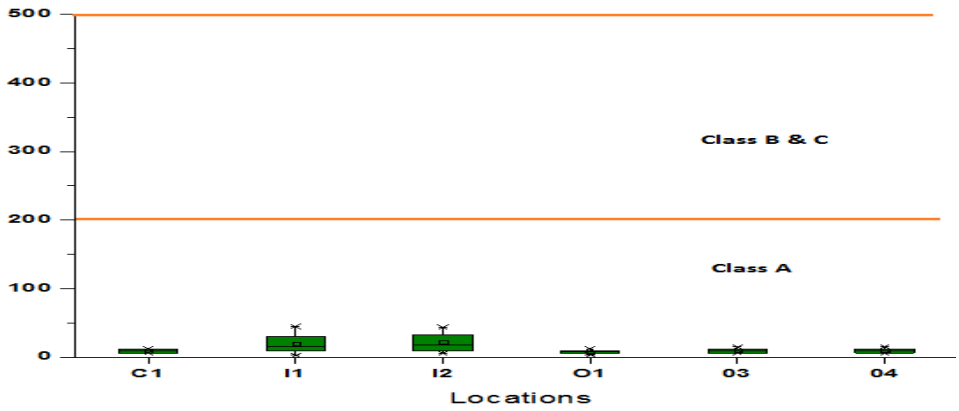


Figure 5.11 Monthly variations in TVOC and CH_2O concentrations in Jaipur

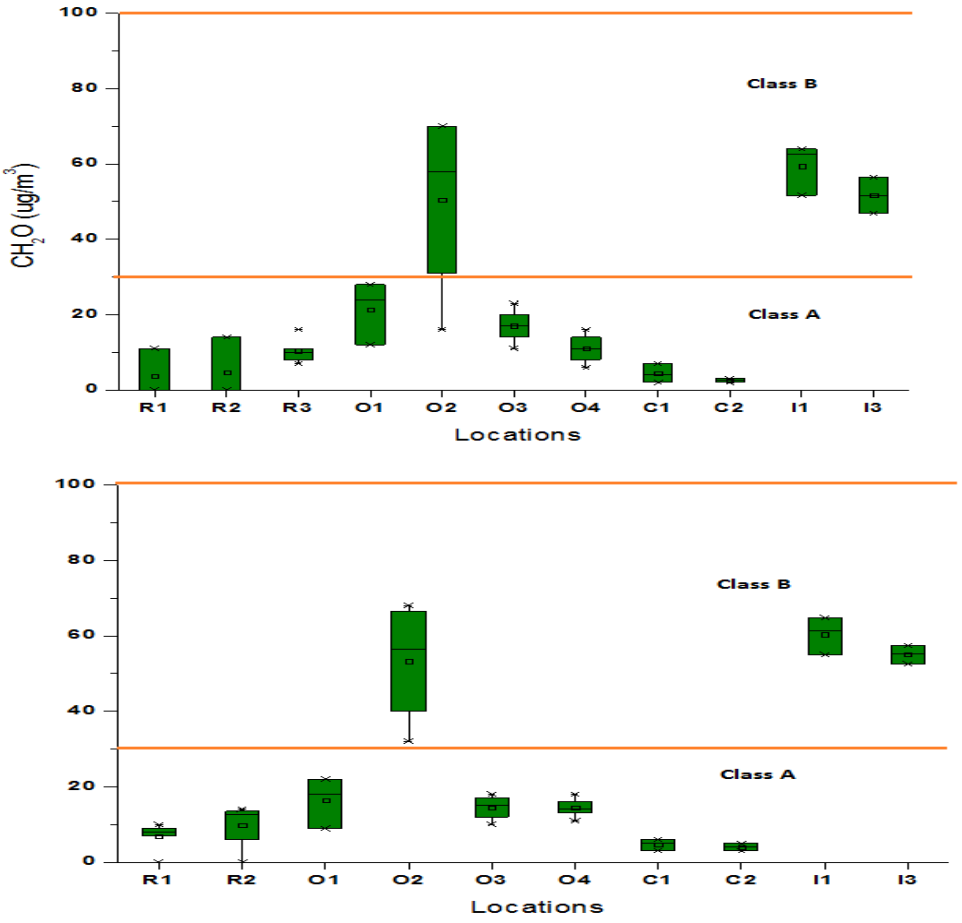
For building OAB and CEEB both TVOC and CH_2O concentrations are found to be in class A range because of both building are very old constructions (39 years and 41 years respectively), paintwork is done long ago and less wooden furniture are used. For residential apartment, both TVOC and CH_2O concentrations are found to be higher as compared to building OAB and CEEB because this is 4-year-old construction and more wood-based products are used as compared to building OAB and CEEB. The highest values of TVOC and CH_2O concentrations among all buildings are measured in kitchen while cooking which is 1140 µg/$m^3$and 390 µg/m^3 respectively.







(a)



(b)

Figure 5.12 Location wise variations in (a) TVOC and (b) CH_2O concentrations for summer, monsoon and winter in Chennai

The location wise variation in TVOC and CH_2O for different monitoring seasons in Chennai is shown in Figure 5.12. The TVOC and CH_2O concentration in all locations was found to be within the compliance zone. The CH_2O concentrations in newly built locations (O2, I1 and I3) was found to be high in all the seasons. However, the CH_2O values for winter season was not monitored due to lack of instrument availability.

5.3.5 SO_2 and NO_2 Concentrations

SO_2 is highly reactive and toxic gas with a pungent, irritating and rotten smell. Emission that leads to high concentrations of SO_2 generally also leads to formation of other oxides of Sulphur (SO_X). Therefore, SO_2 is used as an indicator for a large group of gaseous sulphur oxides. NO_2 is one of the highly reactive gasses known as oxides of Nitrogen (NO_X). In the present study, SO_2 and NO_2 concentration are measured for four months (February 2018 to May 2018). The monthly variations in SO_2 and NO_2 concentrations are shown in Figure 5.13.

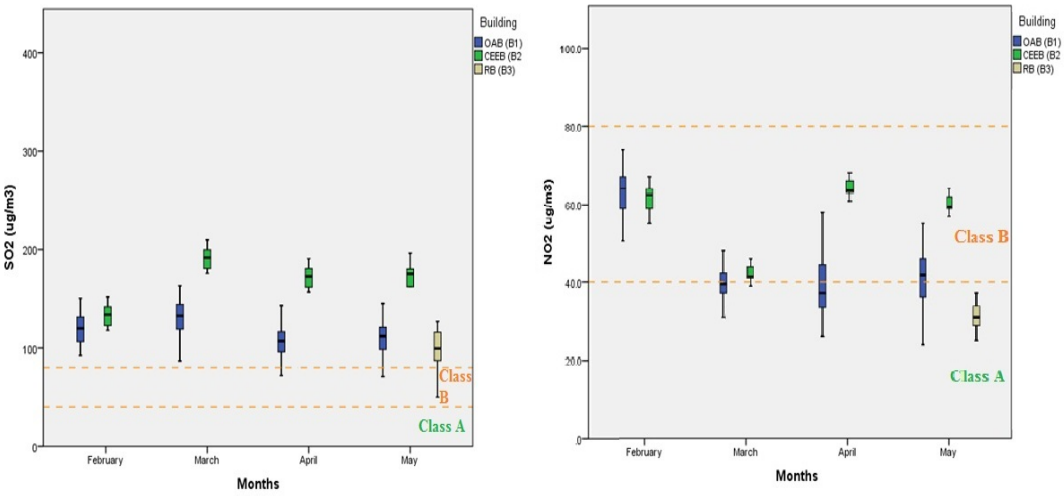
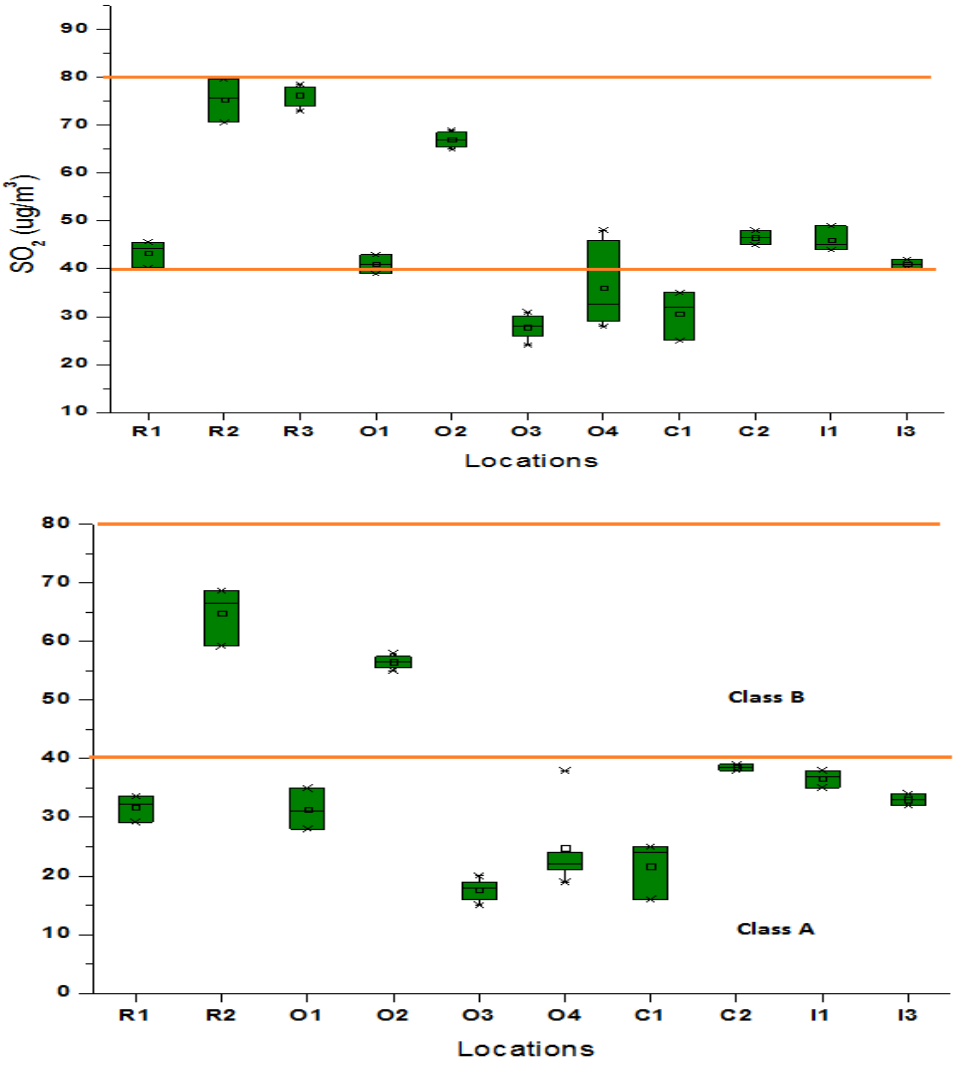


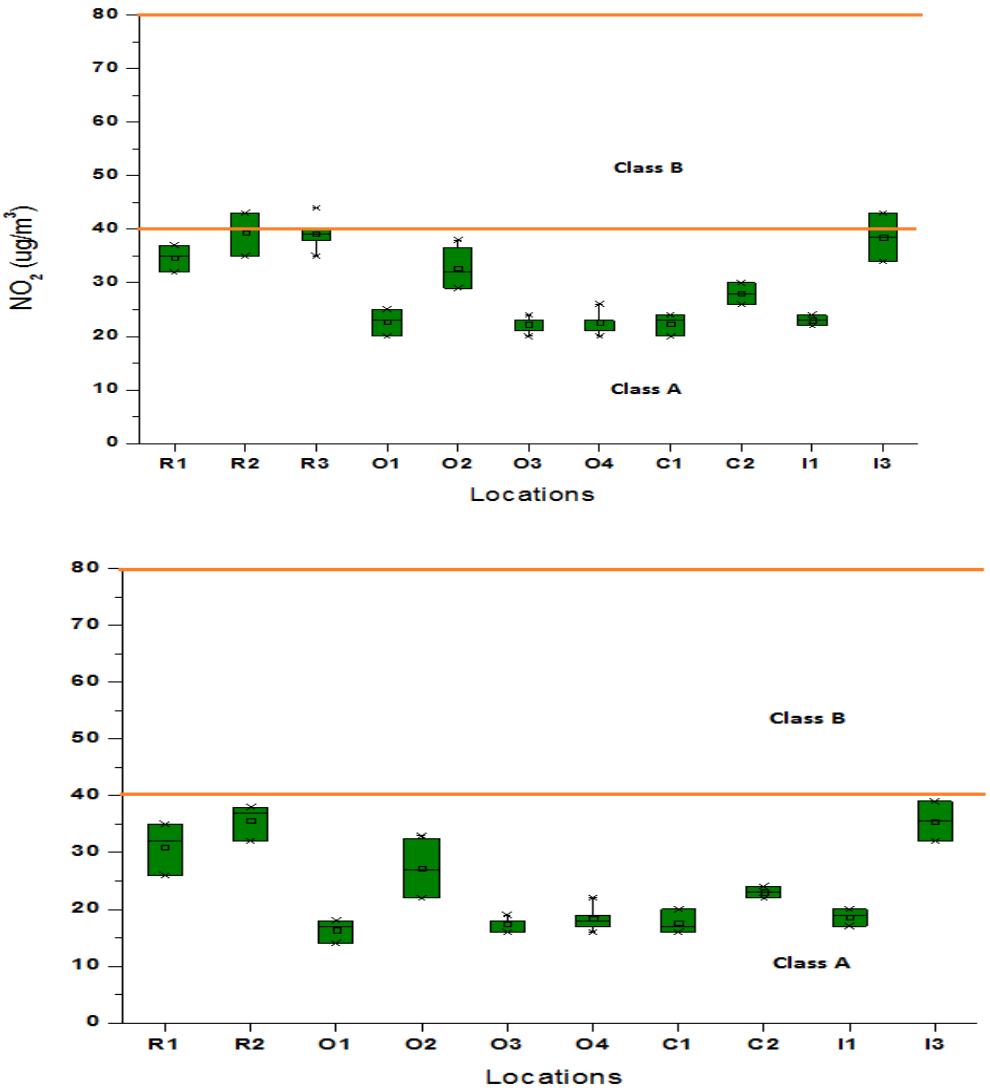
Figure 5.13 Monthly variations in SO_2 and NO_2 concentrations in Jaipur

SO_2 and NO_2concentration found to be higher in building CEEB as compare to OAB because of CEEB is nearer to roadway and vehicles emissions are the major source SO_2 and NO_2. For a residential apartment, both SO_2 and NO_2 concentration are found to be lower as compared to building OAB and CEEB because this is way from heavy traffic roads as compared to building OAB and CEEB. The highest

values of SO_2 and NO_2 concentration in residential apartment are measured in kitchen while cooking which is 410 µg/$m^3$and 156 µg/m^3 respectively.



(a)



(b)

Figure 5.14 Location wise variations in (a) SO_2 and (b) NO_2 concentrations for summer and monsoon season in Chennai

The location wise variation in SO_2 and NO_2 for summer and monsoon seasons in Chennai is shown in Figure 5.14. It was seen that the SO_2 and NO_2 values in both the seasons was within the compliance zone. It was seen that the SO_2 and NO_2 values in buildings (R2, R3, O2) located near road traffic was higher than buildings located inside the background site. The maximum mean SO2 concentration is 76µg/m3 occurred at residential building (R3) located near heavy traffic area and lowest concentration is 28µg/m3 occurred at office building (O3).

Also, it was noticed that SO_2 and NO_2 values in summer was higher than that in monsoon. This is due to the wash out of pollutants in air during the monsoon season.

5.3.6 CO and O_3 Concentrations

CO is colourless, odorless and tasteless gas that is slightly less than air. Ozone is a triatomic compound, very reactive form of oxygen that is a bluish irritating gas of pungent odour. It is a major air pollutant in the lower atmosphere but it beneficial component of the upper atmosphere. In the present study, CO and O_3 concentration are measured for four months (February 2018 to May 2018). The monthly variations in CO and O_3 concentrations are shown in Figure 5.15.

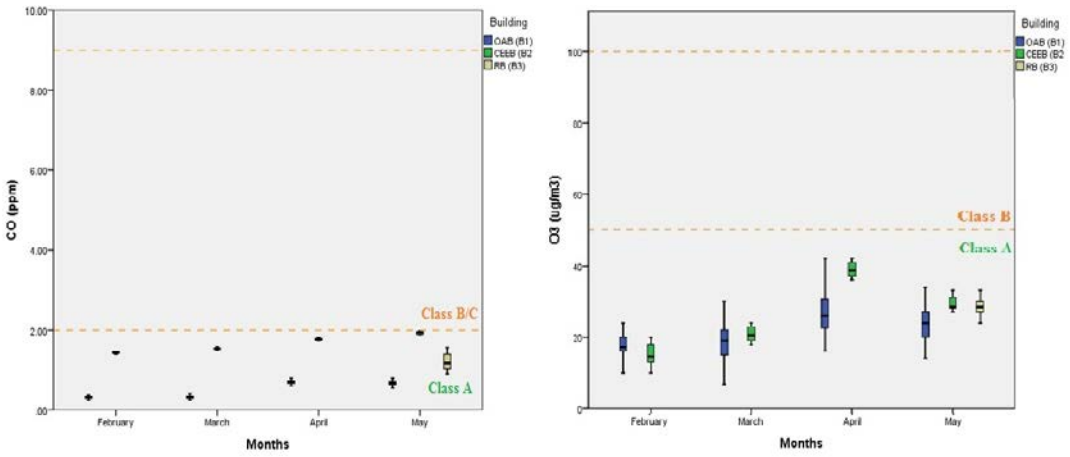
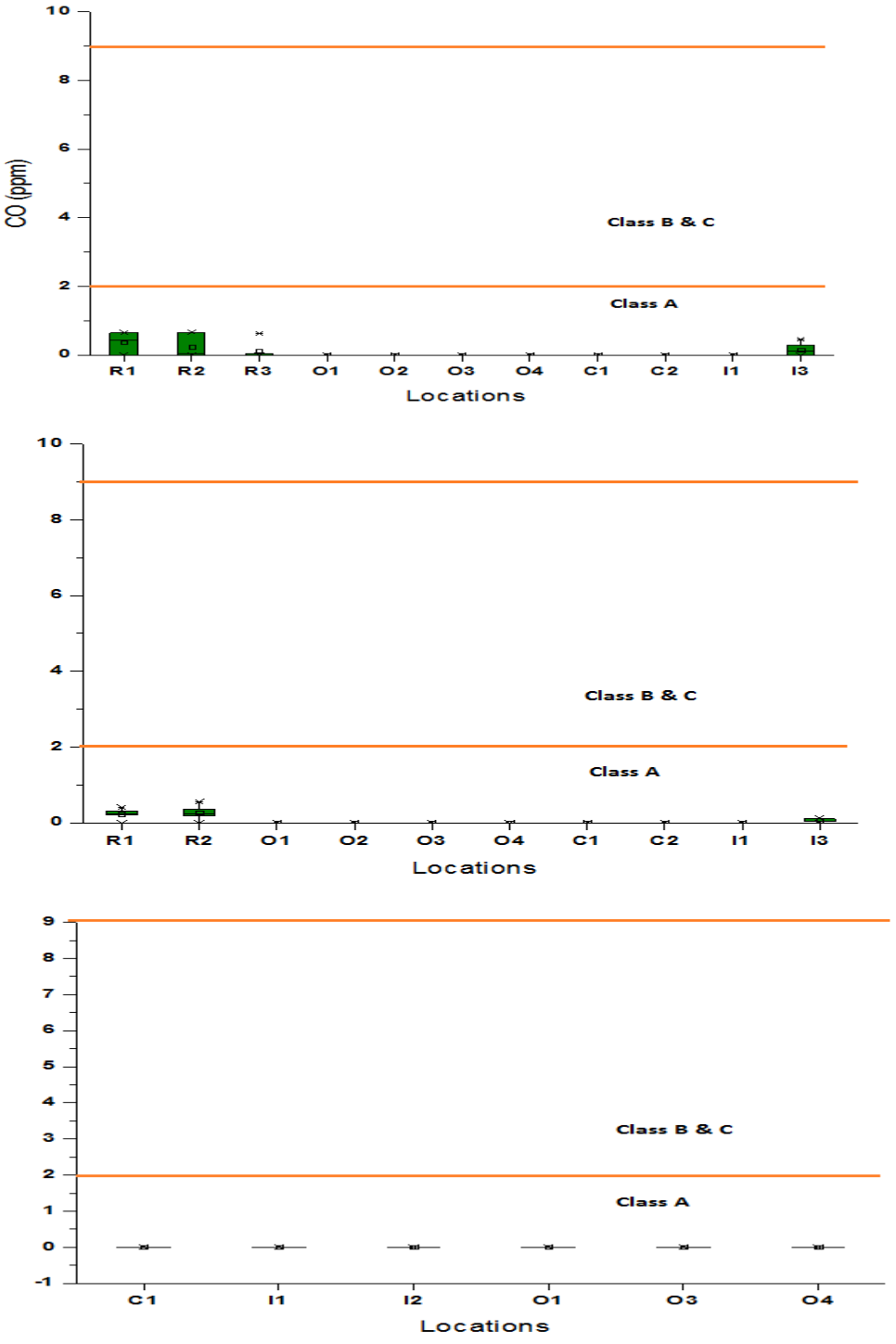


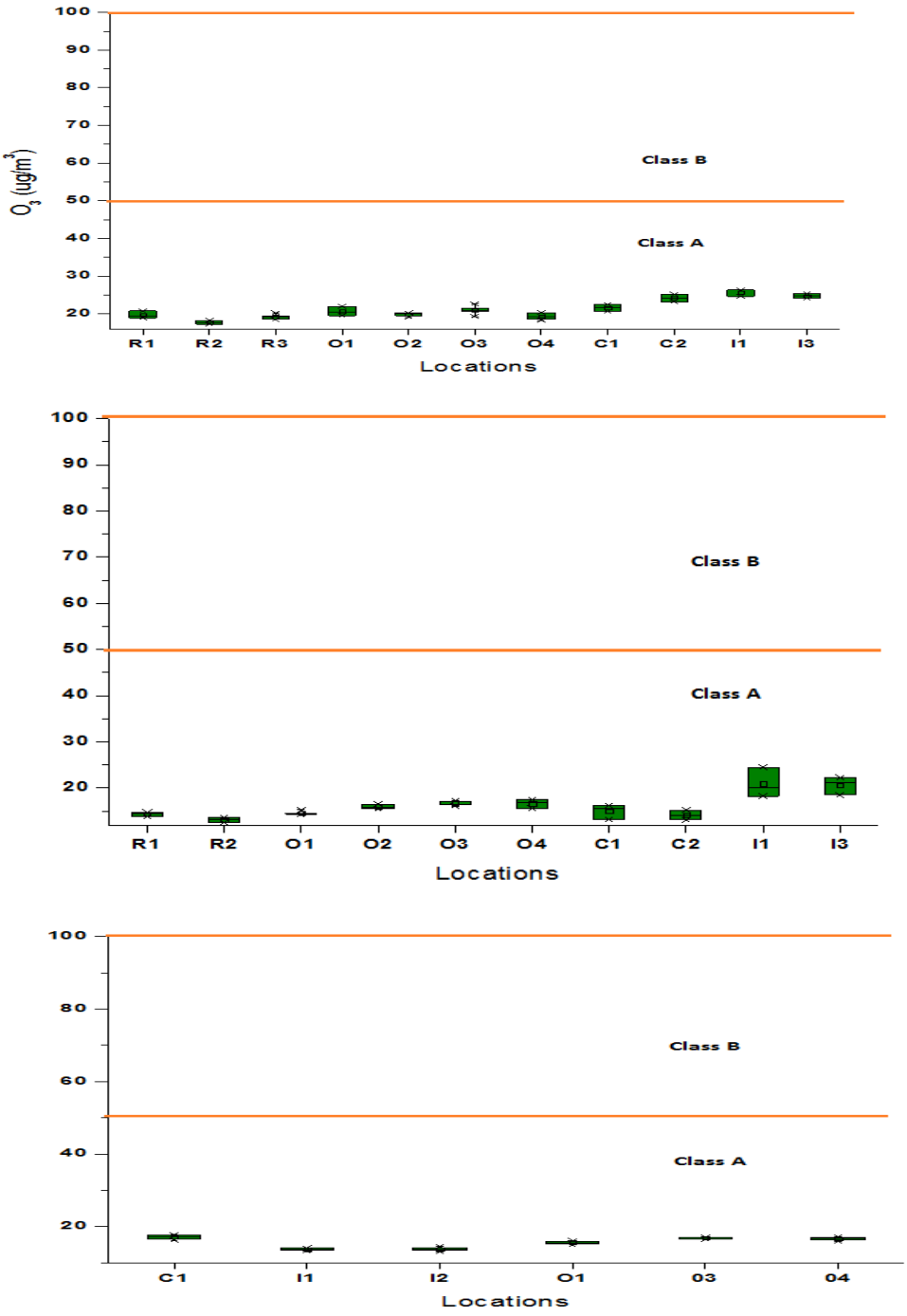
Figure 5.15 Monthly variations in CO and O_3 concentrations in Jaipur

CO concentration found to be higher in building CEEB as compare to OAB because of CEEB is nearer to roadway and vehicles emissions (incomplete combustion) are the major source CO attributes to higher concentration. The highest values of CO concentration (up to 10 ppm) in the residential apartment are measured in kitchen while cooking.

O_3 concentration found to be higher in building CEEB and residential building as compare to OAB because exterior walls of every room, as well as roof of CEEB, is directly exposed to the sunlight. Also, O_3 concentration is observed higher for the month of April and May as compared to the month of February and March because of higher sunlight.


CO (ppm)
10
8
6
4
2
0
Class B & C
Class A
R1
R2
R3
O1
O2
O3
O4
C1
C2
I1
I3
Locations
10
8
6
4
2
0
Class B & C
Class A
R1
R2
O1
O2
O3
O4
C1
C2
I1
I3
Locations
9
8
7
6
5
4
3
2
1
0
-1
Class B & C
Class A
C1
I1
I2
O1
O3
O4
Locations

(a)



(b)

Figure 5.16 Location wise variations in (a) CO and (b) O_3 concentrations for summer, monsoon and winter season in Chennai

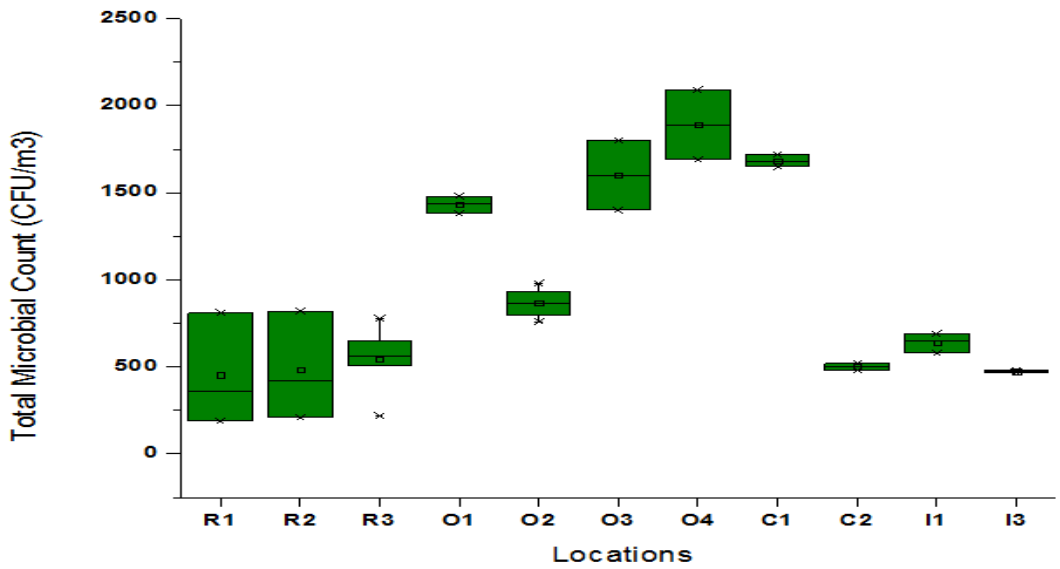
The location wise variation in CO and O_3 for summer and monsoon seasons in Chennai is shown in Figure 5.16. It was seen that the CO concentration in building (R2, R3) located near busy traffic roads are higher than those located inside

the background site. I3 had high CO concentration mainly due to the soldering activity that was done at that location. The values of CO measured in summer was higher and monsoon was minimum.

It was observed that the O_3 concentration was highest in summer and lowest in winter season which may be due to the high solar light intensity obtained in summer season. Also if was seen that the O_3 in departmental stores and I1, I3 where the walls are exposed to sun light was higher.

5.3.7 Total microbial count (TBC)

Total microbial count includes all viable microbes present in air which may include bacteria, mould, fungi, viruses, spores, pollen, animal dander, mites etc. Humans are a source of various bacteria and virus especially sick people can cause a spread of microbes through their saliva and other bodily fluids. Another factor affecting the TBC is outdoor air, which can have significant influence on the diversity and intensity of indoor microbial population. Indoor environmental conditions can affect TBC. As an example high humidity conditions and favorable temperature can lead to the growth of mould on indoor walls, ceilings or other building materials.



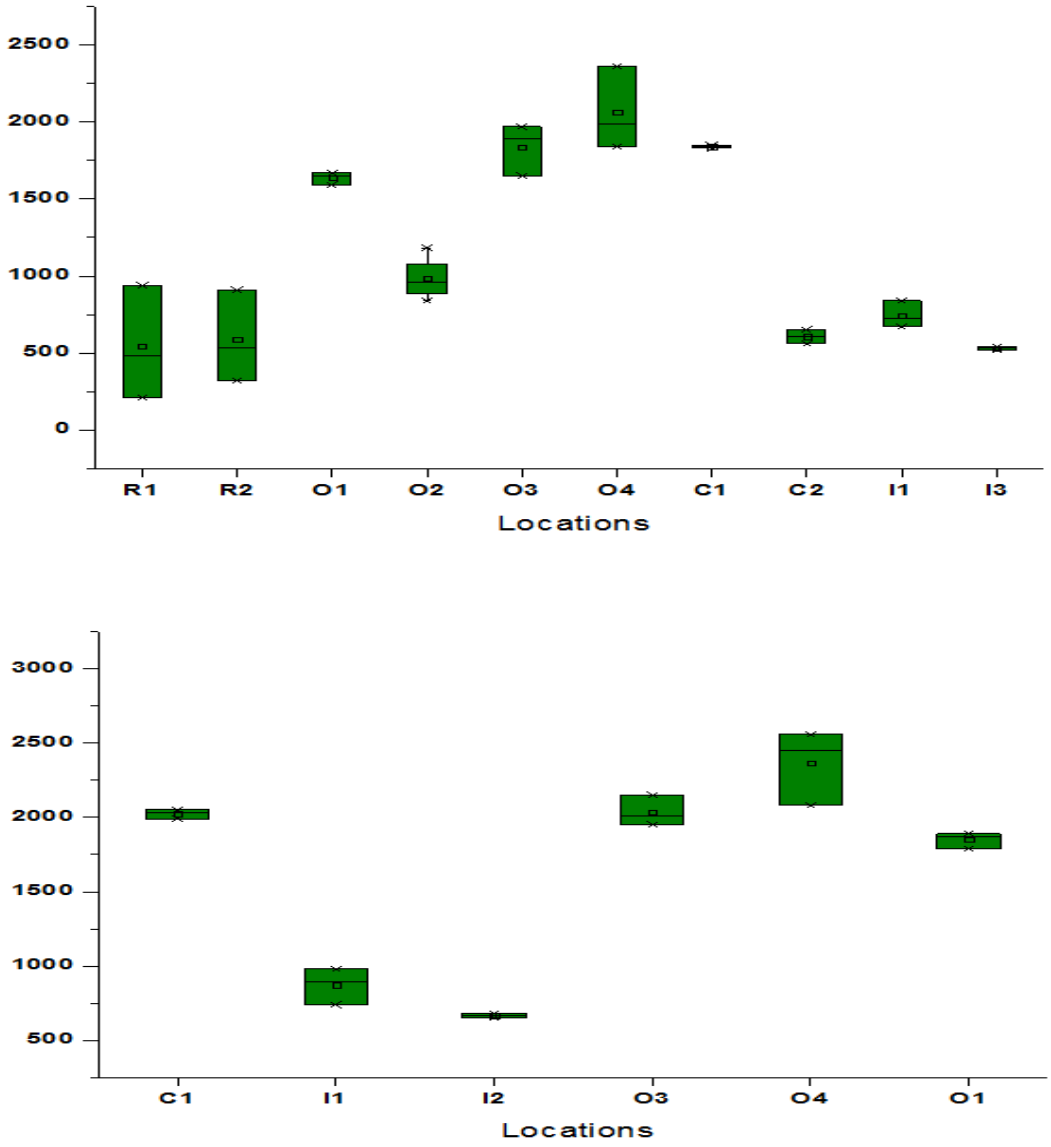


Figure 5.17 Location wise variation in TBC for summer, monsoon and winter season respectively in Chennai

Figure 5.17 shows the location wise variation in TBC for different seasons. The highest value of TBC was observed in winter season and lowest in summer season irrespective of the sampling location. TBC depended on the number of occupants and the type of ventilation being used. The air conditioned office building with higher occupancy showed the highest TBC. The TBC was not dependent on the proximity of sampling site to road traffic, rather the presence of thick vegetation covers inside IITM campus caused higher indoor TBC.

5.3.8 Variation of IAQ Parameters within Room

According to ISHRAE IEQ standard, the common protocol for IAQ parameters measurement location is "shall be measured at least in one location per floor and wind or in one location for each set of rooms with same activity level". In the present study, all IAQ parameters are measured at each and every potential occupant location (as defined in section 4.3). Further, to verify the ISHARE IEQ standard protocol, the team analysed the standard deviation of different IAQ parameters separately for every room for the complete study period. This analysis expresses how much the IAQ parameters deviate from mean values within a room and also gives understanding where to take a measurement in a room. For complete study, mean value of standard deviation for concentrations of CO_2, CO, PM 2.5, PM 10, TVOC, CH_2O, SO_2, NO_2 and O_3 are found to be 8 ppm, 0.18 ppm, 0.91µg/m^3, 3.42µg/m^3, 1.95µg/m^3, 1.71µg/m^3, 5.2µg/m^3, 1.72µg/m^3 and 1.58µg/m^3. The monthly variations in standard deviation for CO_2, PM 2.5, PM 10, CH_2O, SO_2, NO_2, O_3, TVOC and CO concentrations are shown in Figure 5.18 to Figure 5.22.

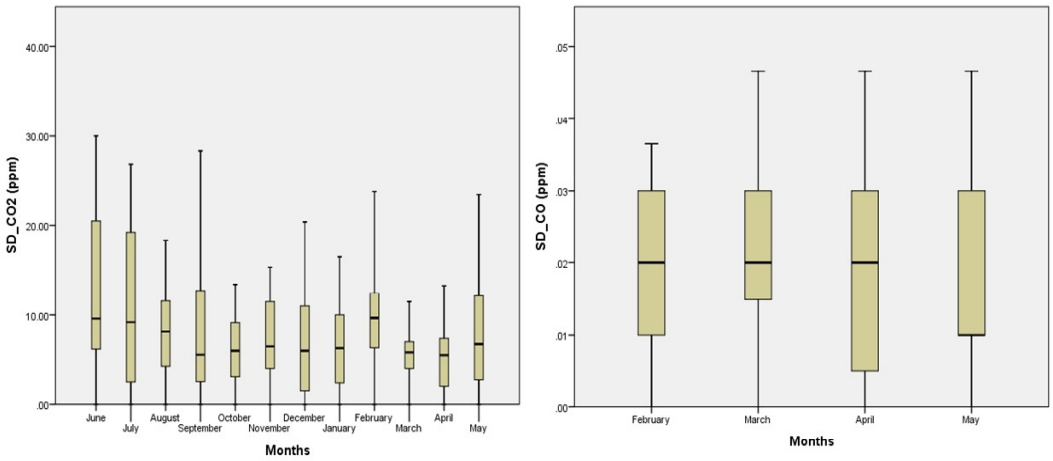


Figure 5.18 Monthly variations in standard deviation for CO_2 and CO concentrations in Jaipur

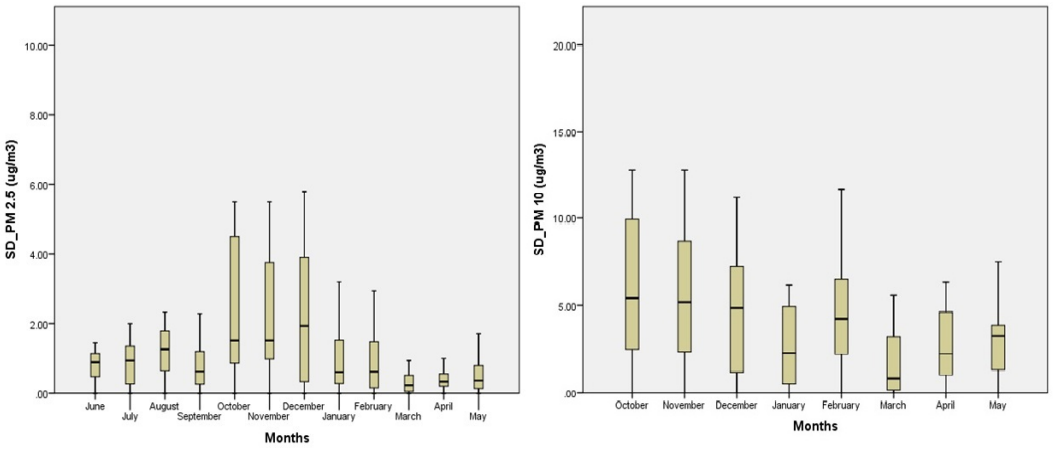


Figure 5.19 Monthly variations in standard deviation for PM 2.5 and PM 10 concentrations in Jaipur

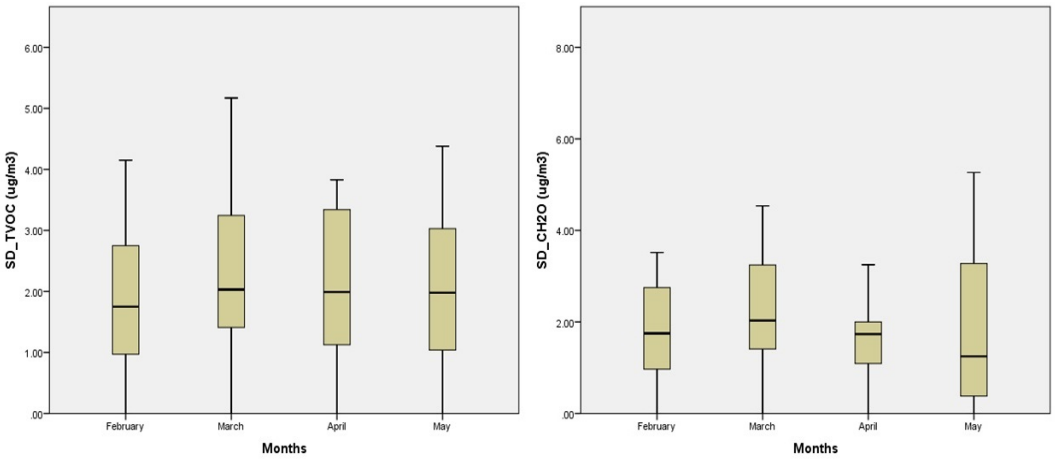


Figure 5.20 Monthly variations in standard deviation for TVOC and CH_2O concentrations in Jaipur

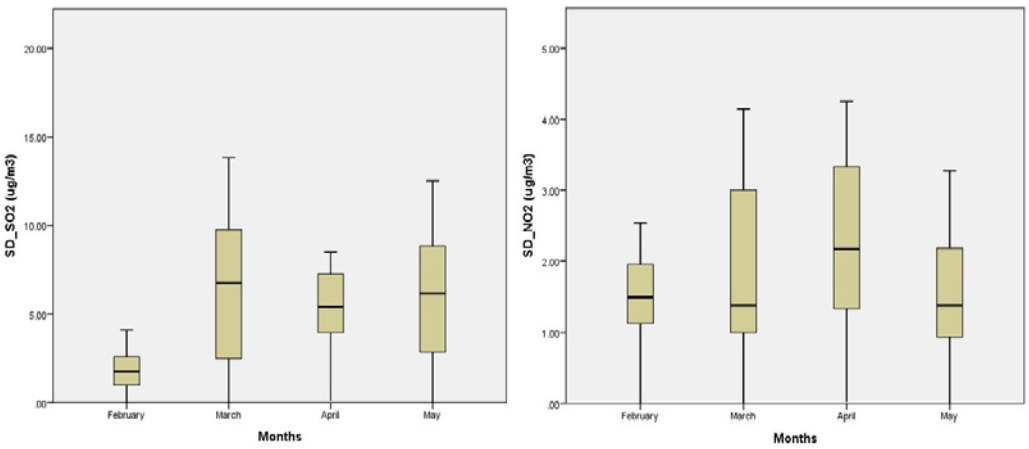


Figure 5.21 Monthly variations in standard deviation for SO_2 and NO_2 concentrations in Jaipur

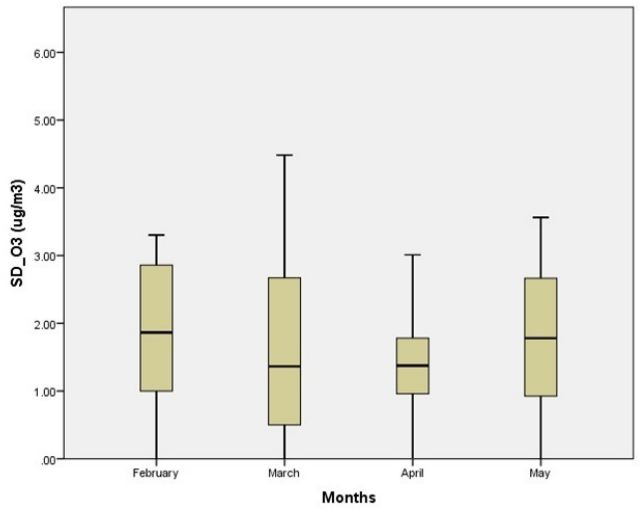


Figure 5.22 Monthly variations in standard deviation for O_3 concentrations in Jaipur

5.3.9 Variation in IAQ Parameters between Indoor and Air Intake

According to ISHRAE IEQ standard, the protocol for some of IAQ parameters measurement location is "shall be measured at possible fresh air intake in the room (AHU air intake or air vent or open window)". In the present study, the team measured CO_2, CO, PM 2.5, PM 10, SO_2, NO_2 and O_3 concentrations at the possible fresh air intake in the room as well. Monthly variation in CO_2, CO, PM 2.5, PM 10, SO_2, NO_2 and O_3concentrations between indoor and air intake in the room is presented in Figure 5.23 to Figure 5.26. The concentration of $CO_2$is measured at each potential occupant locations in the room has at least 90% occupancy. Due to high natural vegetation in MNIT campus, the ambient CO_2 concentration is found to be 400± 25 ppm. The two major elements influencing CO_2 concentration are observed to be the fresh air intake and occupancy. Due to occupancy, the CO_2 concentration is found to be higher in the indoor as compare to the fresh air intake. CO_2 concentration at fresh air intake is same as outdoor.

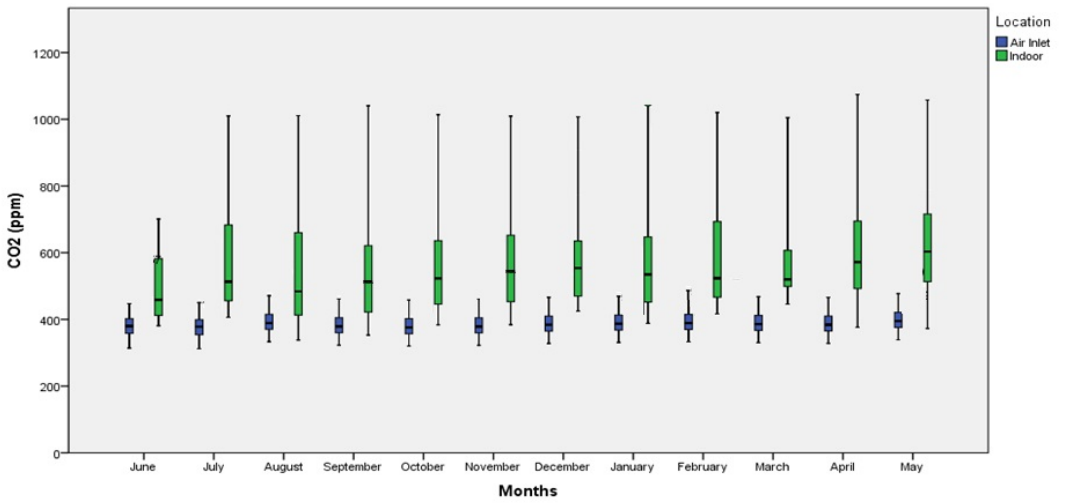
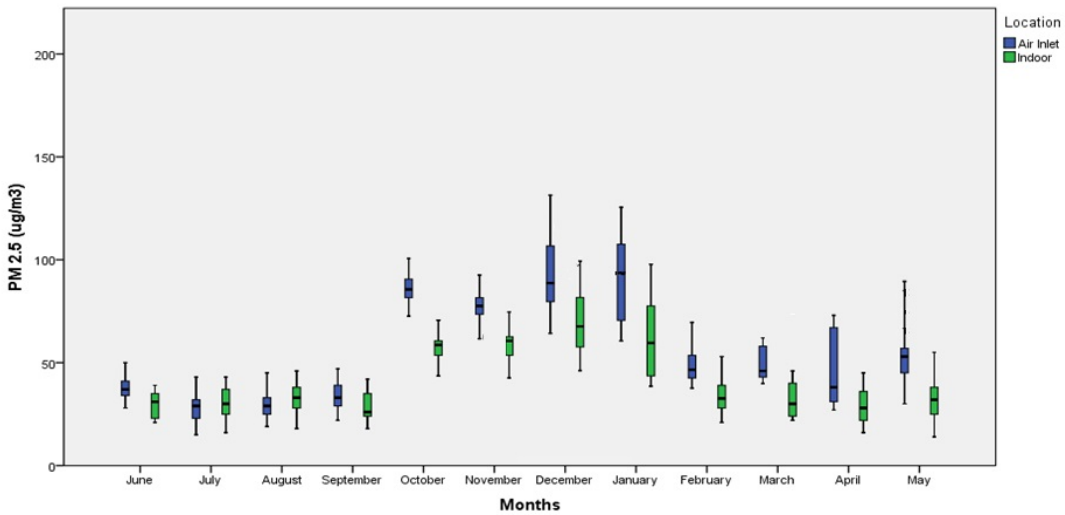
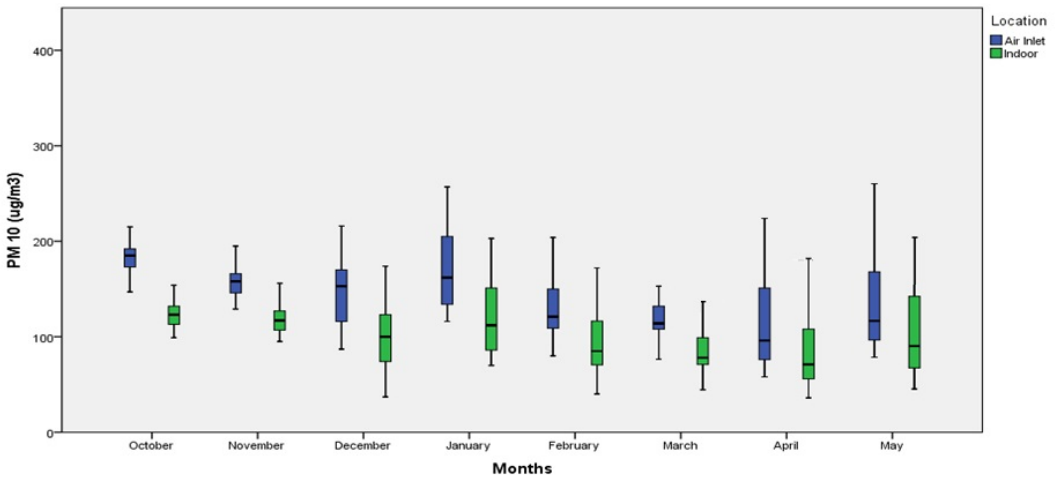


Figure 5.23 Monthly variations in CO_2 concentrations between indoor and air intake in Jaipur

Both PM 2.5 and PM 10 concentrations are found to lower in the indoor for all seasons except the monsoon season. In monsoon season, the lower concentrations of particulate matters are observed due to the fact of washout of the particles from the atmosphere. Further, for the month of October and May both PM 2.5 and PM 10 concentrations are observed higher in air intake as compare to other months which is due the effect of Diwali festival (Celebrated in India) in which a huge amount of busting of firecrackers happens in the month of October and in the month of May the dust storm hit north-west India.



(a)



(b)

Figure 5.24 Monthly variations in (a) PM 2.5 (b) PM 10 concentrations between indoor and air intake in Jaipur

SO_2 and NO_2 concentration found to be higher at air intake as compare indoor because of vehicles emissions are the major source SO_2 and NO_2. Similarly, CO concentration found to be air intake as comparing indoor vehicles emissions (incomplete combustion) are the major source CO. O_3concentration is observed higher at air intake as compare indoor because of higher sunlight. Further, ambient ground-level O_3 is not emitted directly into the air, but is created by chemical reactions between NO_X and VOCs in the presence of sunlight, causes higher values of ozone concentrations at air intake as compared to indoor.

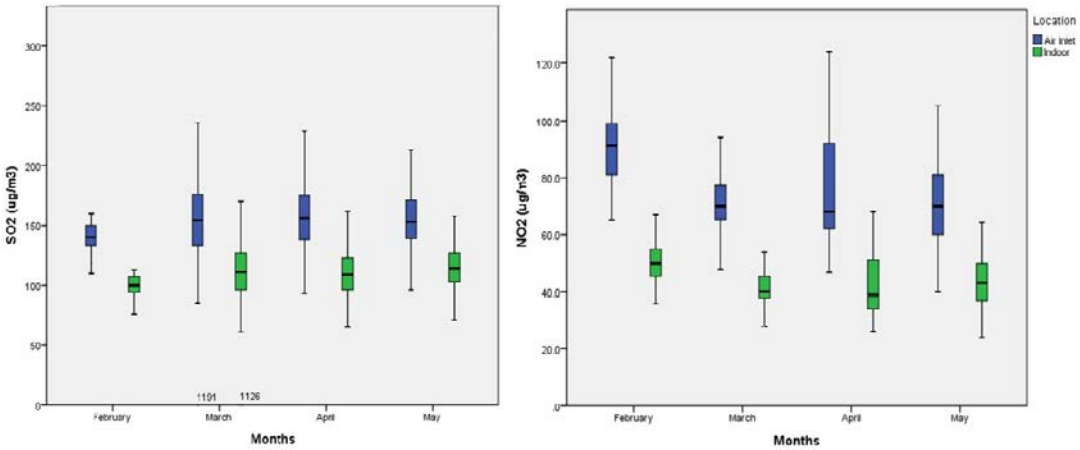


Figure 5.25 Monthly variations in SO_2 and NO_2 concentrations between indoor and air intake in Jaipur

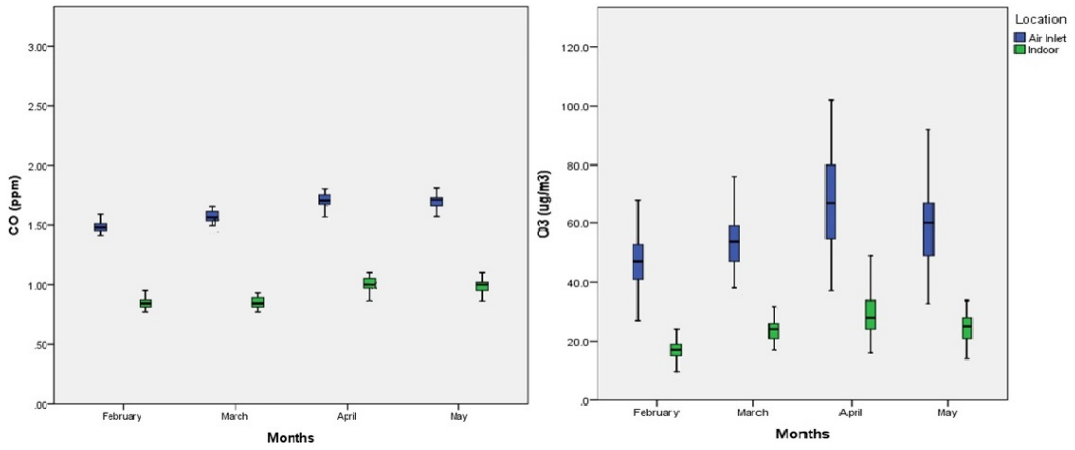
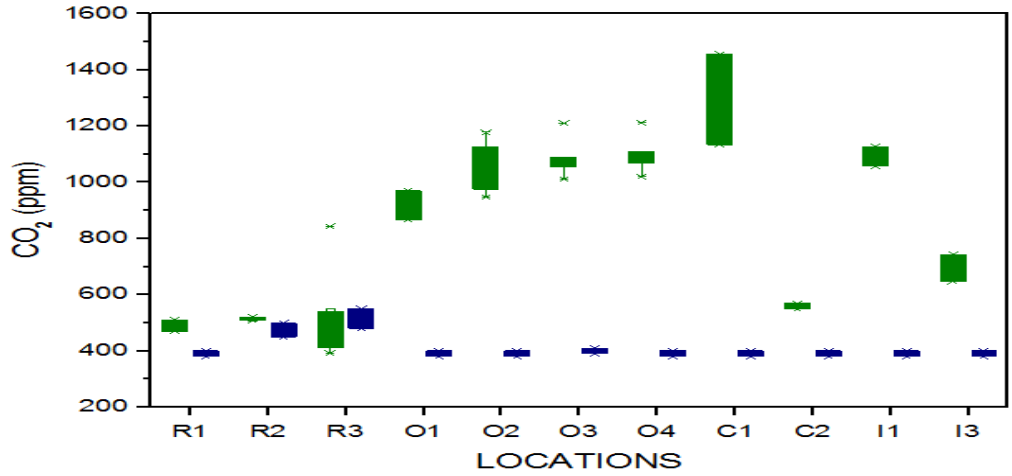
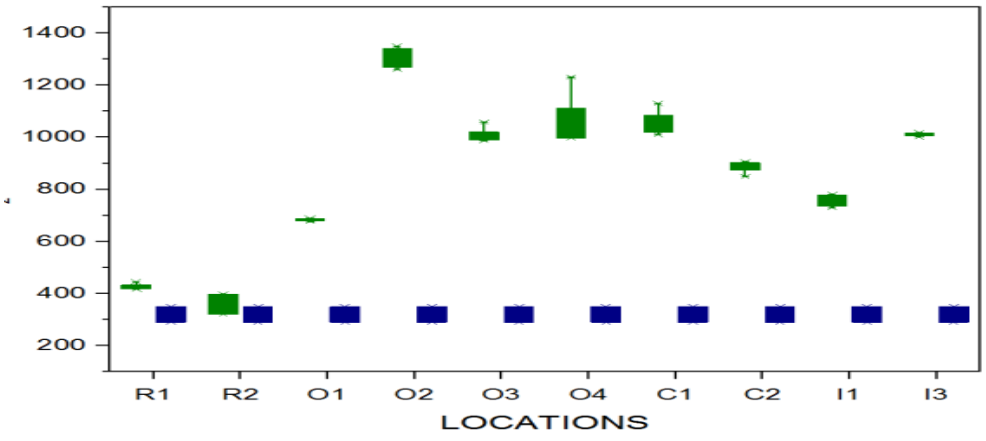


Figure 5.26 Monthly variations in CO and O_3 concentrations between indoor and air intake in Jaipur





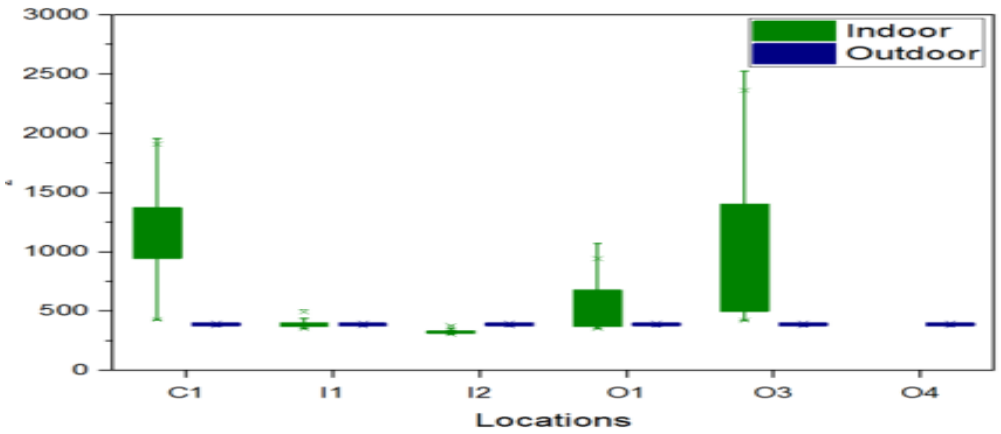
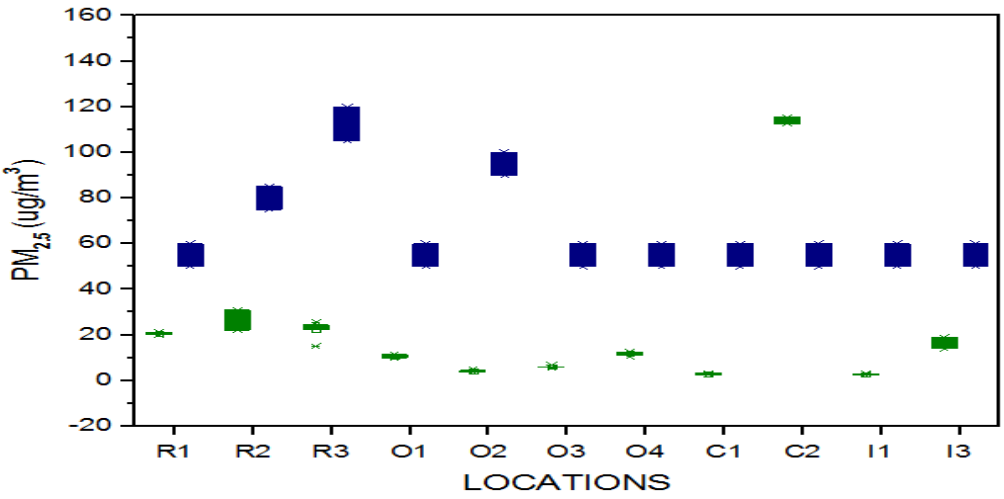


Figure 5.27 Location wise variations in indoor and outdoor CO_2 concentration for summer, monsoon and winter season in Chennai

Figure 5.27 shows the location wise variations in indoor and outdoor CO_2 concentration for different season monitored in Chennai. It was seen that the outdoor CO_2 concentration was about 390±20 ppm throughout the monitoring period. The indoor CO_2 concentrations in offices and institutional buildings were higher than the corresponding outdoor concentration mainly due to the higher occupancy and dependence on air conditioning for ventilation which further leads to be accumulation of CO_2 levels in indoor spaces.



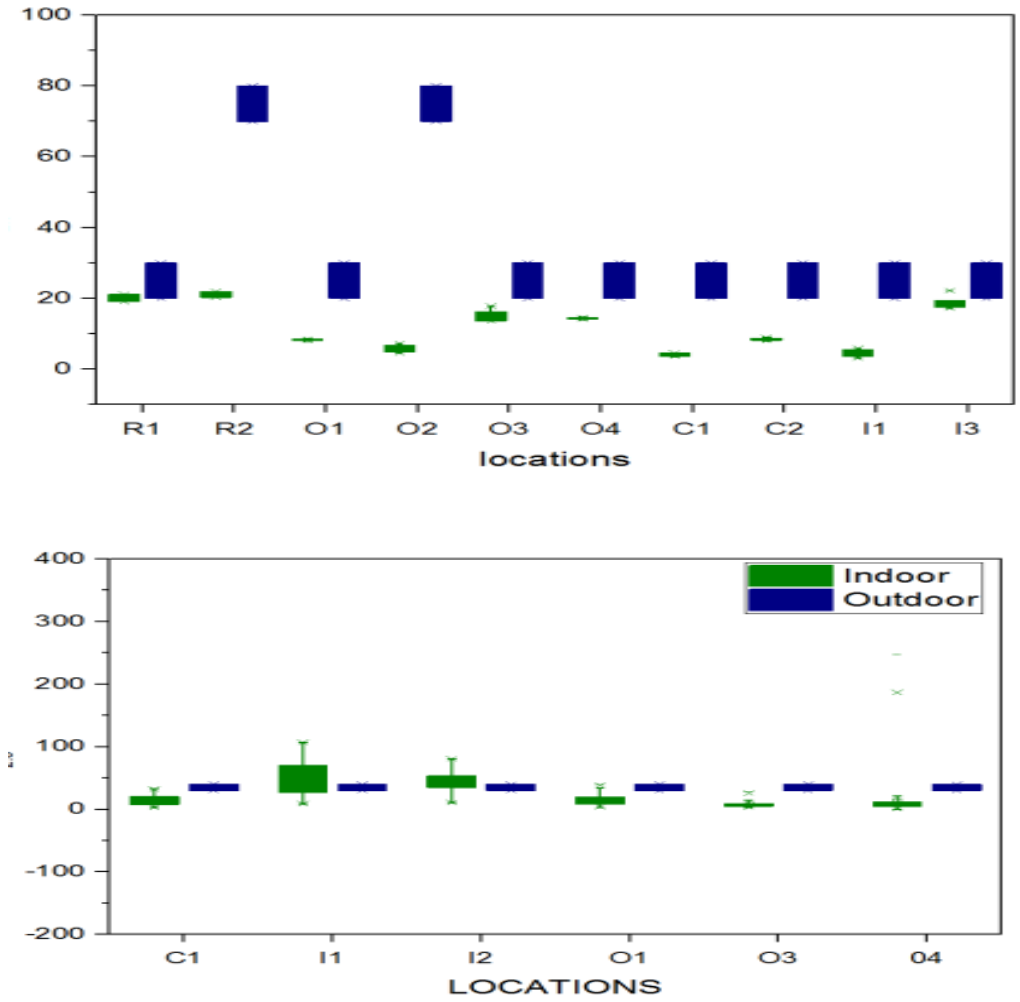
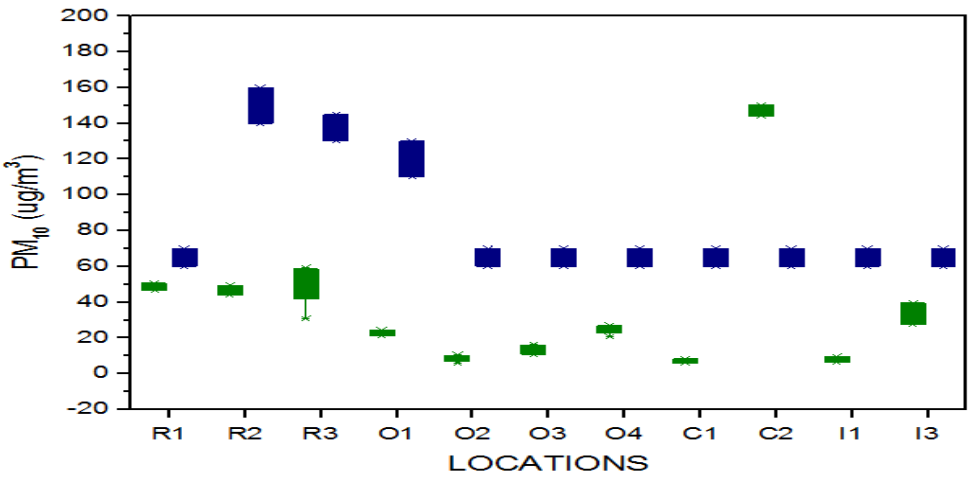


Figure 5.28 Location wise variations in indoor and outdoor $PM_{2.5}$ concentrations for summer, monsoon and winter season in Chennai



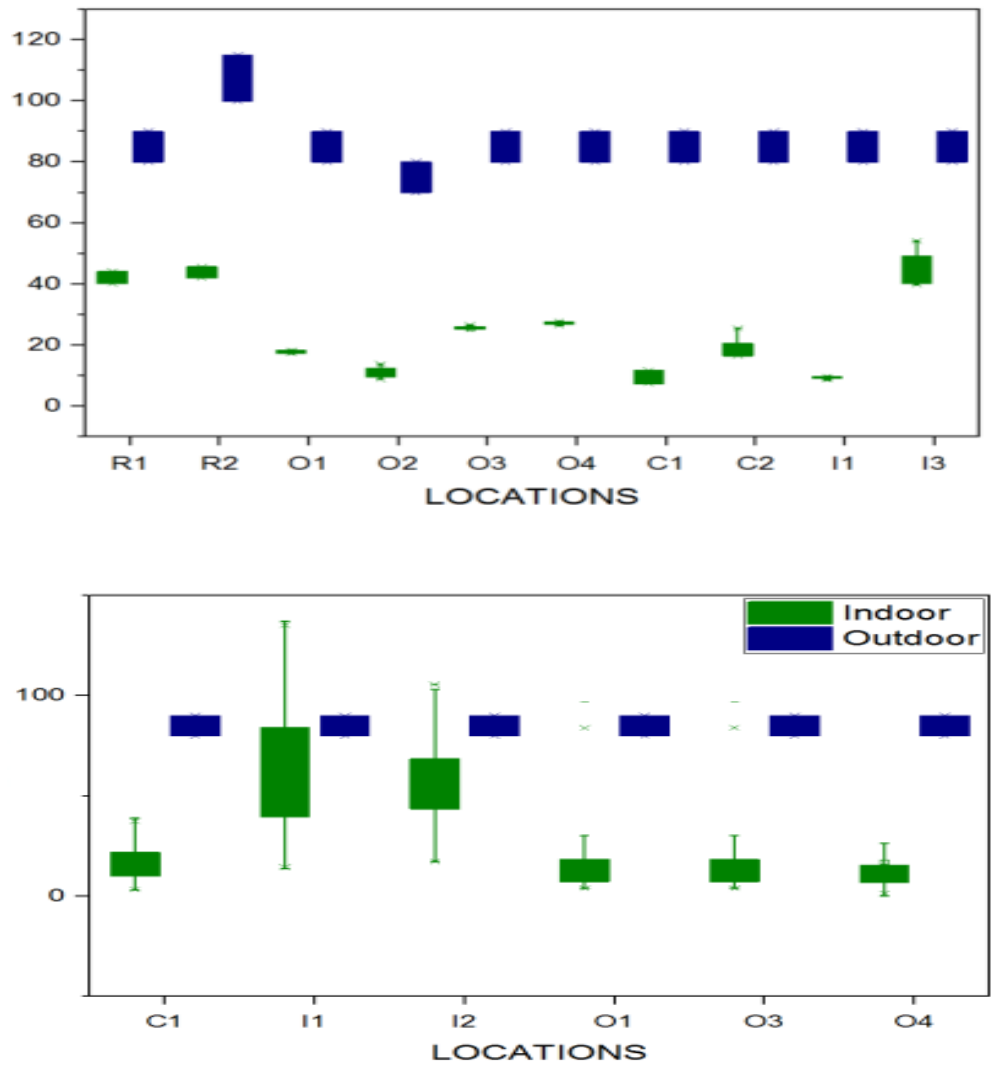


Figure 5.29 Location wise variations in indoor and outdoor PM_{10} concentration for summer, monsoon and winter season in Chennai

Figure 5.28 - Figure 5.29 and shows the location wise variations in indoor and outdoor $PM_{2.5}$ and PM_{10} concentration for different season monitored in Chennai. It was seen that the outdoor PM concentration was higher than the indoor levels in most of the cases. This signifies the impact of outdoor PM concentration on the indoor levels. In cases where predominant indoor source (dust from resuspension and high intensity occupant activity) is present as in C2, the indoor level was found to be higher than the outdoor levels. The PM concentration in I1 and I2 was high due to the construction activities that happened during the monitoring period.

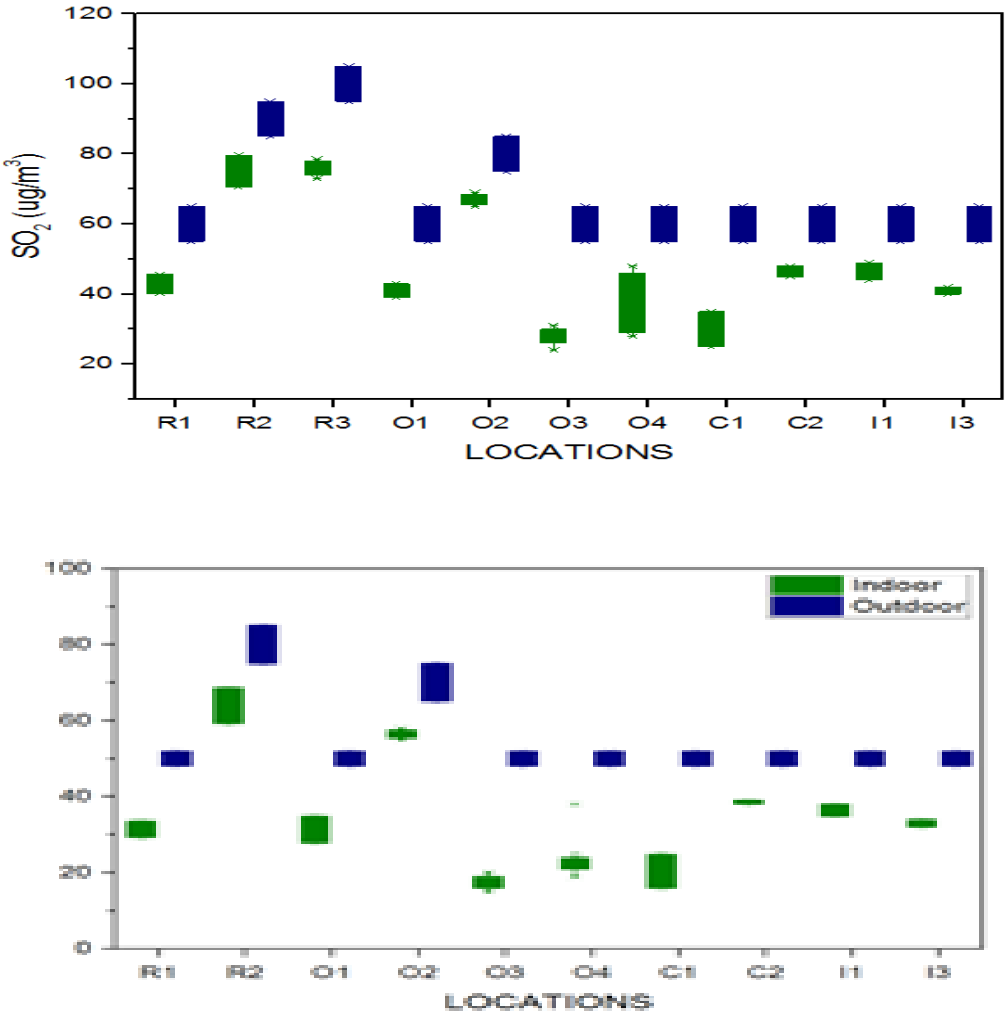


Figure 5.30 Location wise variations in indoor and outdoor SO_2 concentration for summer and monsoon season in Chennai

Figure 5.30 shows the location wise variations in indoor and outdoor SO_2 concentration for different season monitored in Chennai. It was seen that the outdoor SO_2 concentration was higher than the indoor levels at all the locations. There were no indoor sources of SO_2 in any locations monitored. Clearly, outdoor SO_2 levels influenced the indoor concentrations at all locations. The outdoor SO_2 levels at those locations outside the background site (O2, R2, R3) was high due to higher vehicular traffic in those areas.

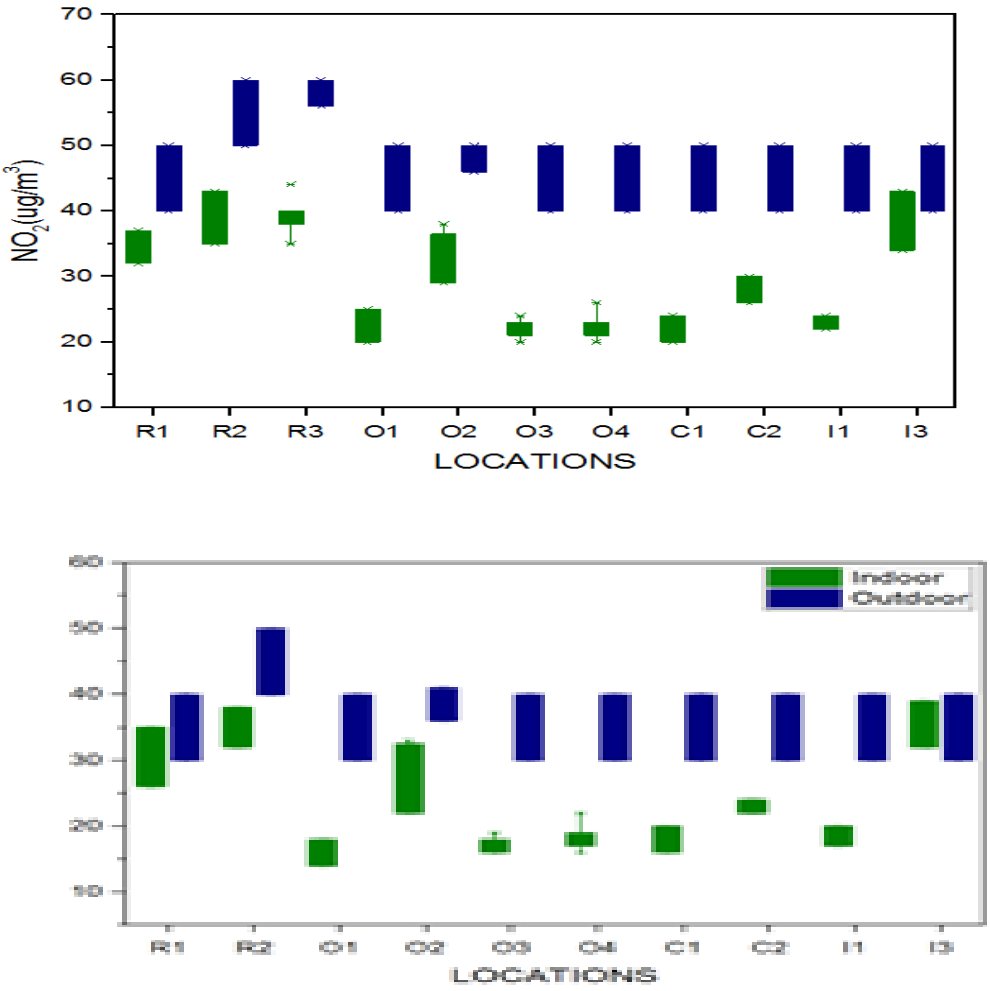


Figure 5.31 Location wise variations in indoor and outdoor NO_2 concentration for summer, monsoon and winter season in Chennai

Figure 5.31 shows the location wise variations in indoor and outdoor NO_2 concentration for different season monitored in Chennai. It was seen that the outdoor NO_2 concentration was higher than the indoor levels at all the locations. There were no indoor sources of NO_2 in most of the locations monitored except I3 where soldering activity was found to influence the indoor NO_2 concentration. NO_2 is produced from high temperature combustion activities like vehicular exhaust emission or burning activities. The outdoor NO_2 levels at those locations outside the background site (O2, R2, R3) was high due to higher vehicular traffic in those areas.

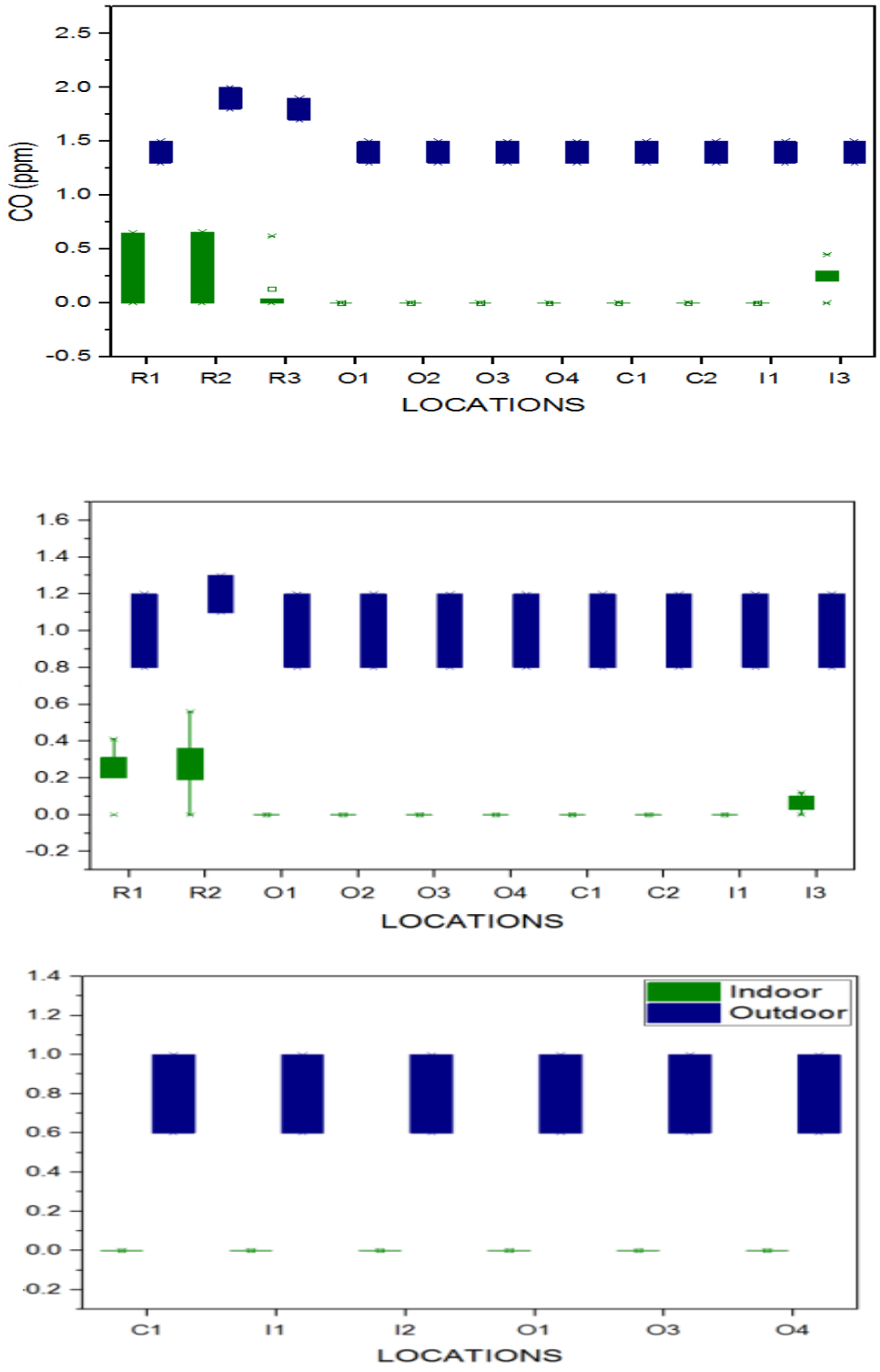


Figure 5.32 Location wise variations in indoor and outdoor CO concentration for summer, monsoon and winter season in Chennai

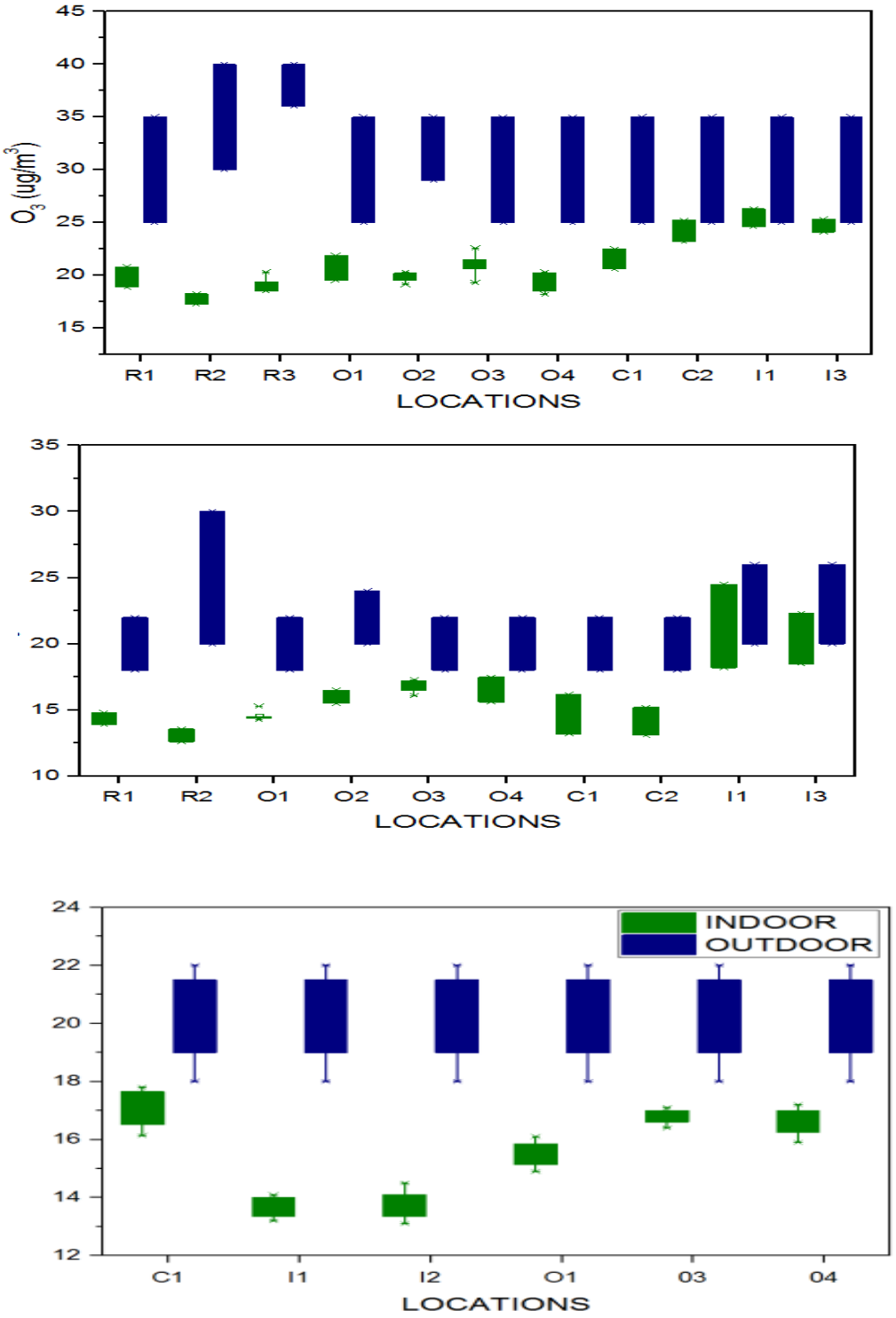
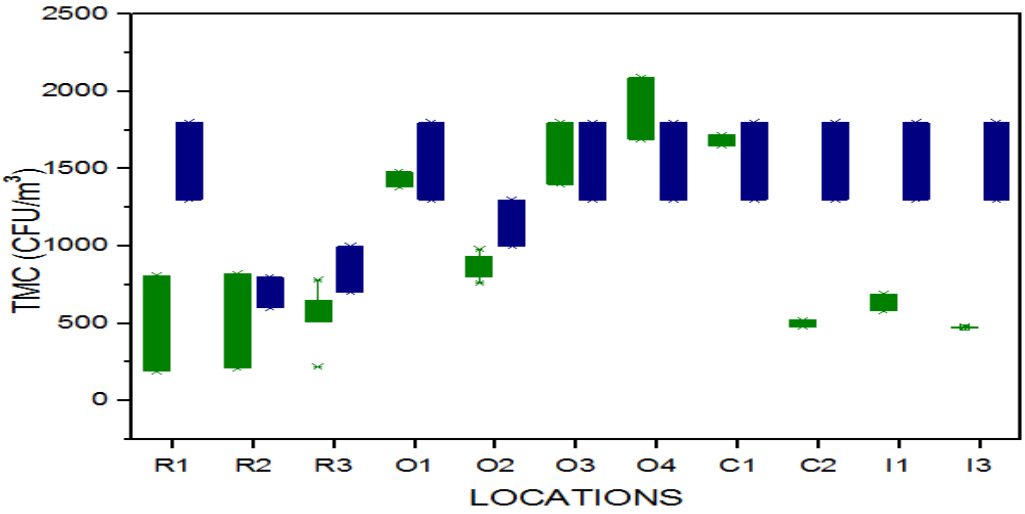
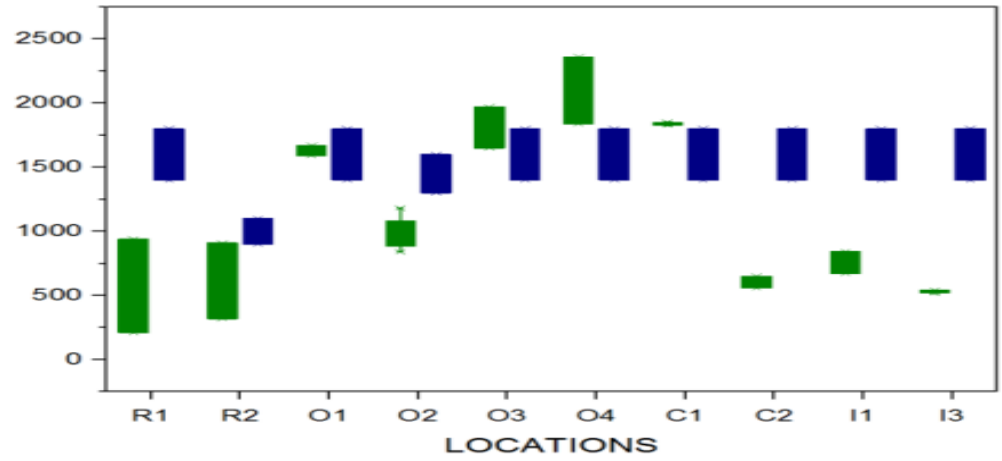


Figure 5.33 Location wise variations in indoor and outdoor O_3 concentration for summer, monsoon and winter season in Chennai

Figure 5.33 and shows the location wise variations in indoor and outdoor CO and O_3 concentration respectively for different season monitored in Chennai. It was seen that the outdoor CO and O_3 concentration was higher than the indoor levels at all the locations. CO is mainly produced from incomplete combustion activities mainly cooking in residences and soldering activity in I3. O3 levels in locations outside the highly vegetated background site was higher due to higher sun light received by these areas.





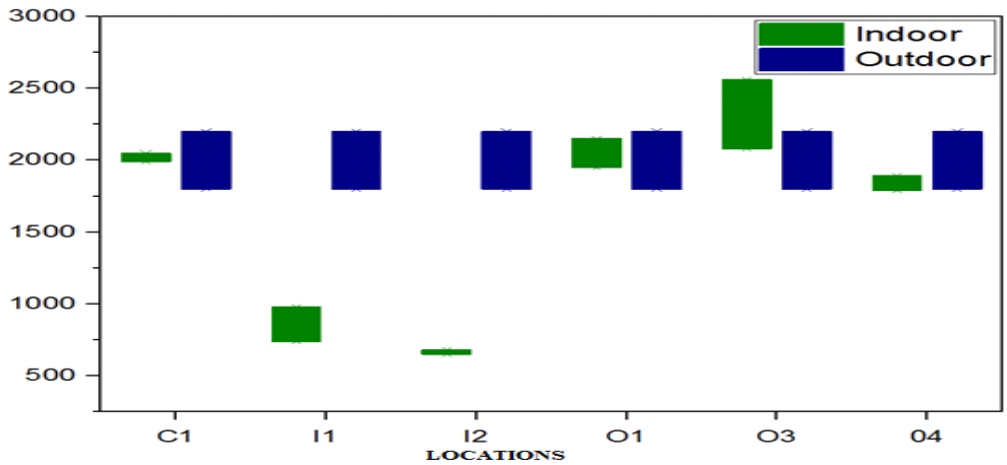


Figure 5.34 Location wise variations in indoor and outdoor total microbial count concentration for summer, monsoon and winter season in Chennai

Figure 5.34 shows the location wise variations in indoor and outdoor total microbial count for different season monitored in Chennai. It was seen that in some locations the indoor total microbial count exceeded the corresponding outdoor levels. Also the outdoor total microbial concentration in background site was higher due to the thick vegetation cover present in this area. Indoor total microbial count was higher than outdoor levels in offices and institutional buildings with high occupancy.

5.4 Lighting comfort

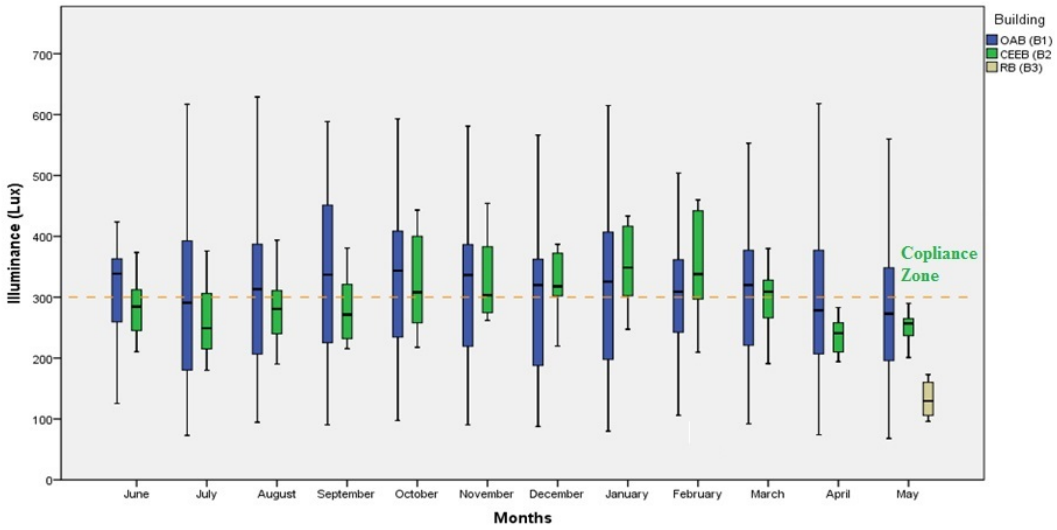
5.4.1 Introduction

Lighting is another contributing factor to IEQ which influences many bodily functions like the nervous system, circadian rhythms, pituitary gland, endocrine system, pineal gland, and alertness) due to its different wavelength. Lighting comfort is the function of various parameters such as illuminance, circadian lighting design, uniformity of illuminance within the task area and a ratio of illuminance of task area to immediately adjacent surroundings at different occupant locations.

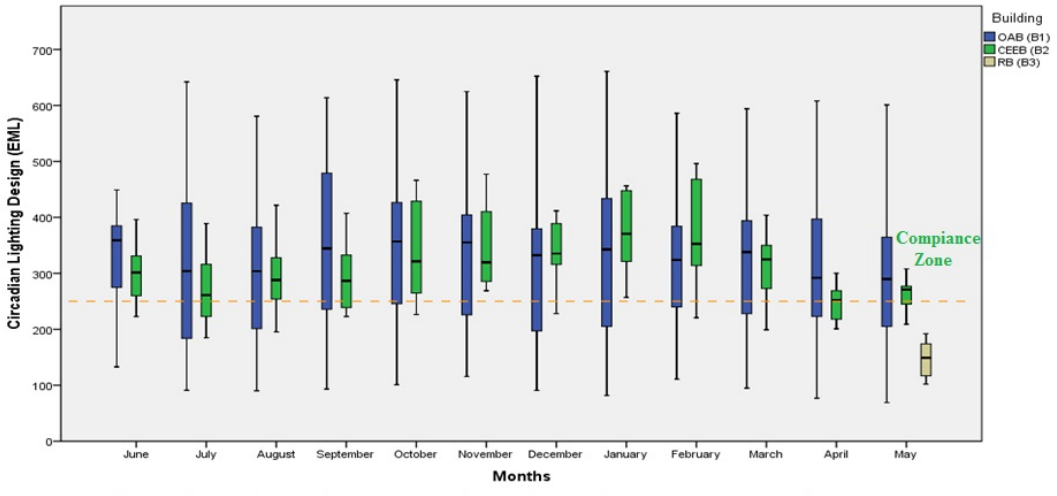
5.4.2 Illuminance and Circadian Lighting Design

Illuminance and circadian lighting design are interrelated with each other. The equivalent melanopic lux (EML) is the measurement of circadian lighting design and can be calculated by multiplying the illuminance (Lux) and melanopic ratio. The EML expresses the biological effects of light on the human body.

Whereas, the melanopic ratio is the function of CCT and light source type. In the present study, most of the rooms in both buildings are having a fluorescent lamp (with CCT 6500K) except two rooms (having LED) located in OAB. In the present study, the mean value of illuminance for summer, monsoon, post-monsoon, winter, and moderate seasons are found to be 286 Lux, 310 Lux, 335 Lux, 346 Lux and 316 Lux respectively. Further, the mean value of circadian lighting design for summer, monsoon, post-monsoon, winter, and moderate seasons are found to be 304 EML, 328 EML, 354 EML, 365 EML and 334EML respectively. Also, the monthly variations of illuminance and circadian lighting design are depicted in Figure 5.35.



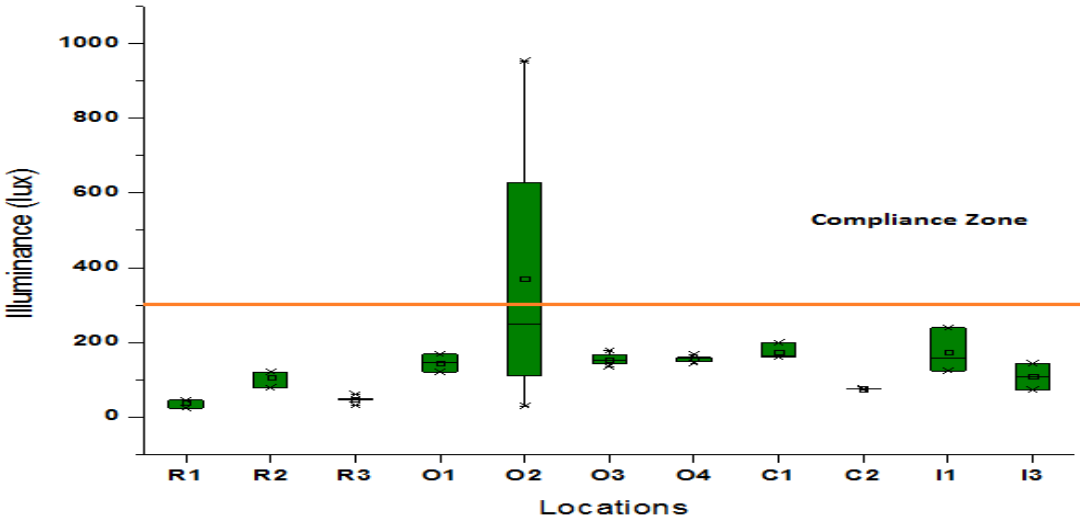
(a)

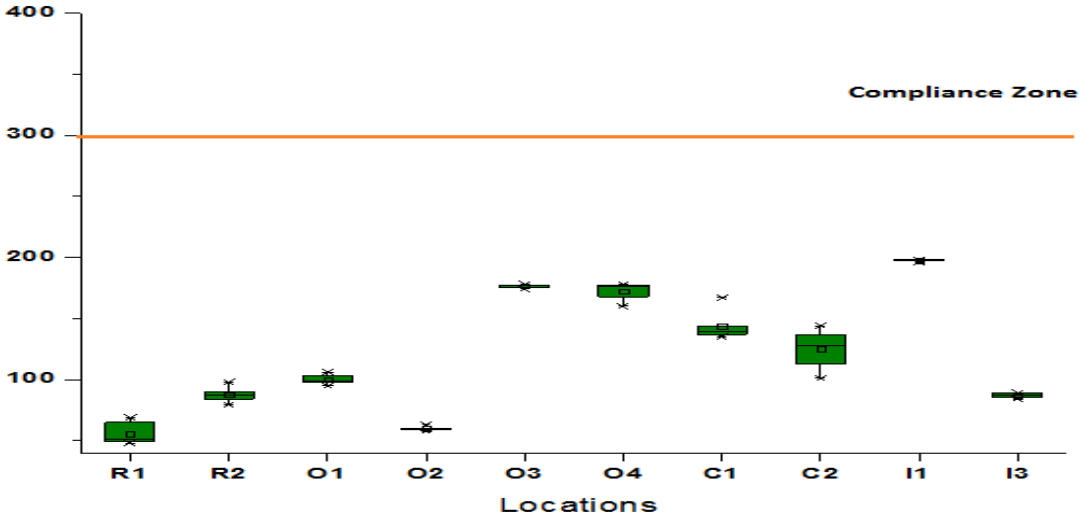


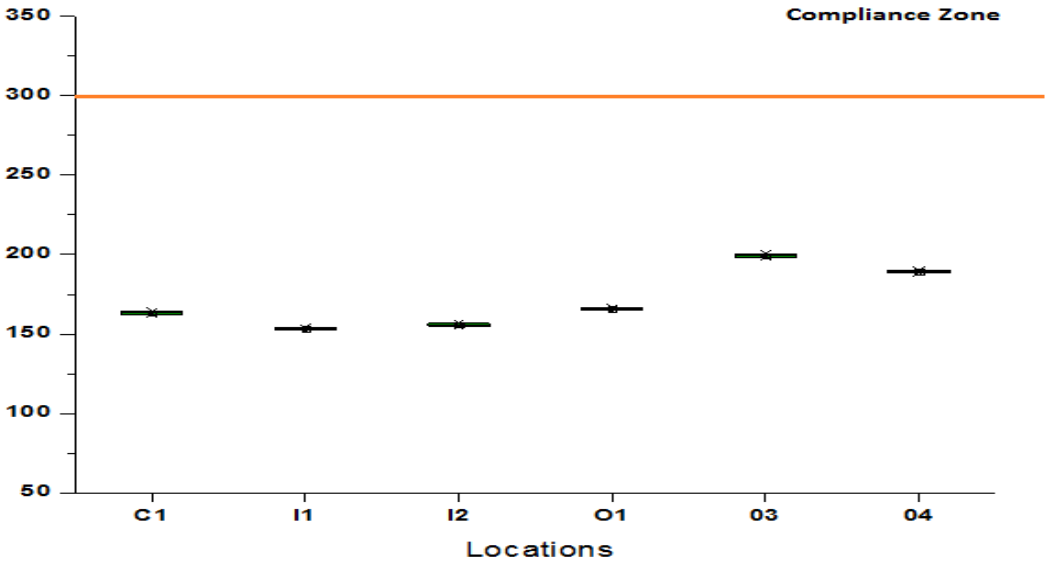
(b)

Figure 5.35 Monthly variations in (a) illuminance and
(b) circadian light design in Jaipur

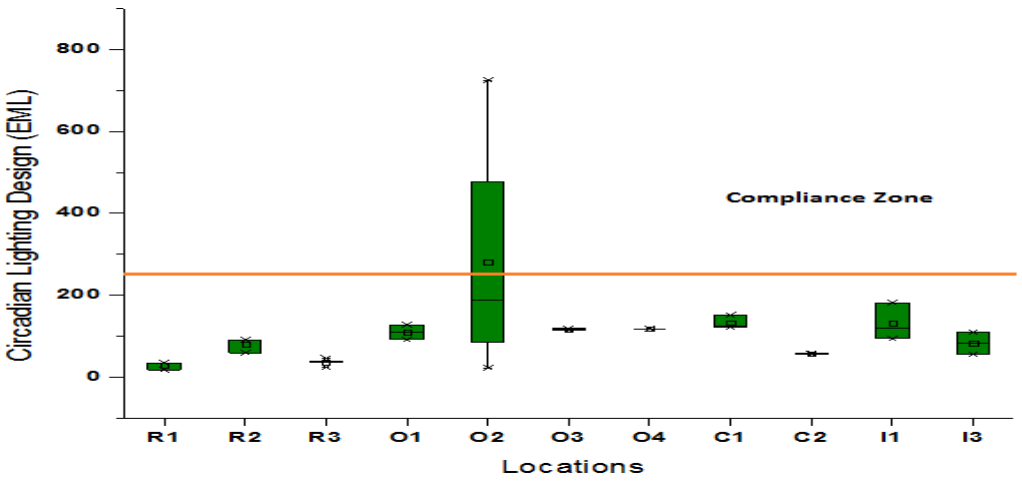
The Monsoon season shows relatively lower mean values of illuminance and circadian lighting design because of the low daylight due to overcast cloud cover. Conversely, for the month of October, both are recorded maximum because of the clear sky. Also, the winter season shows relatively high values of illuminance and circadian lighting design because of the occupants' tendency to gain more solar heat through the opening of window blinds and curtains attributed to enhance the daylight. Further, the summer season shows relatively lower values of illuminance and circadian lighting design because of the occupants' tendency to reduce solar heat through closing of window blinds and curtains attributed to decrease in the daylight. Since EML related to daylighting is substantially more than artificial lighting and thus the former not only provides better amount of light but also saves electricity. As compared to CFL, the Lux and EML related to LED are lower due to the facts that the LED is having lower CCT (4000 K) and Melanopic ratio (0.76).

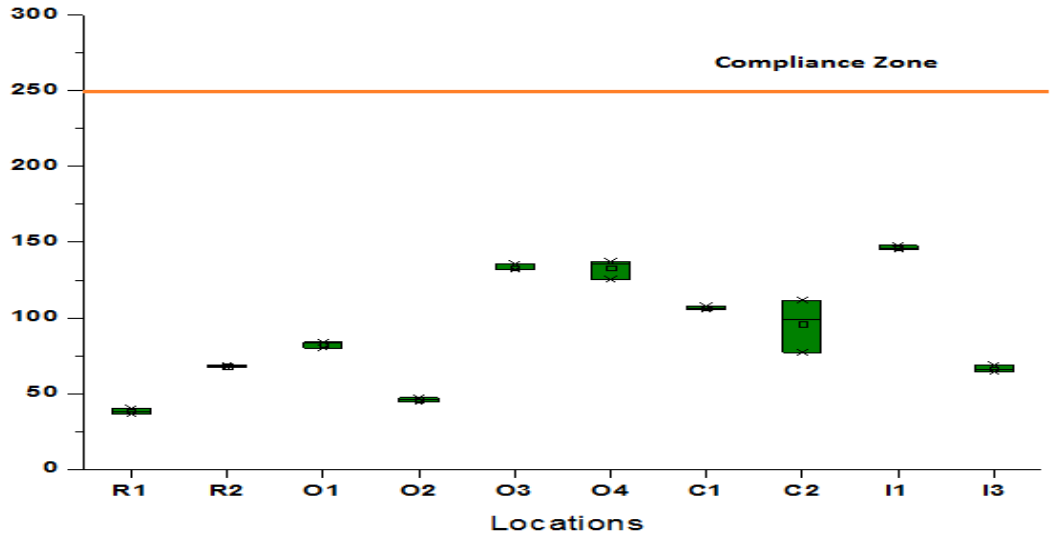


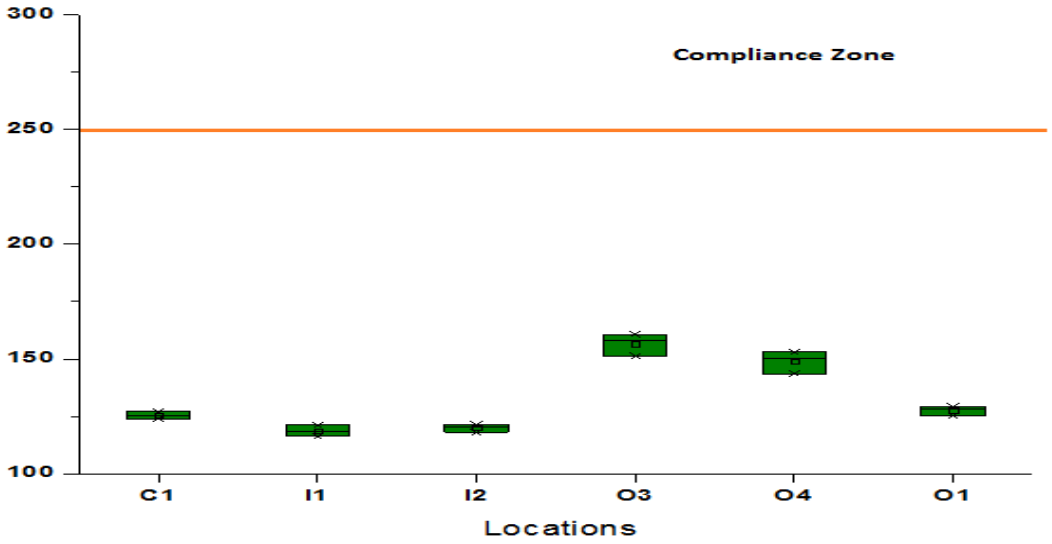

400
300
200
100
Compliance Zone
R1
R2
O1
O2
O3
O4
C1
C2
I1
I3
Locations


350
300
250
200
150
100
50
Compliance Zone
C1
I1
I2
O1
03
04
Locations

(a)


800
600
400
200
0
Circadian Lighting Design (EML)
Compliance Zone
R1
R2
R3
O1
O2
O3
O4
C1
C2
I1
I3
Locations





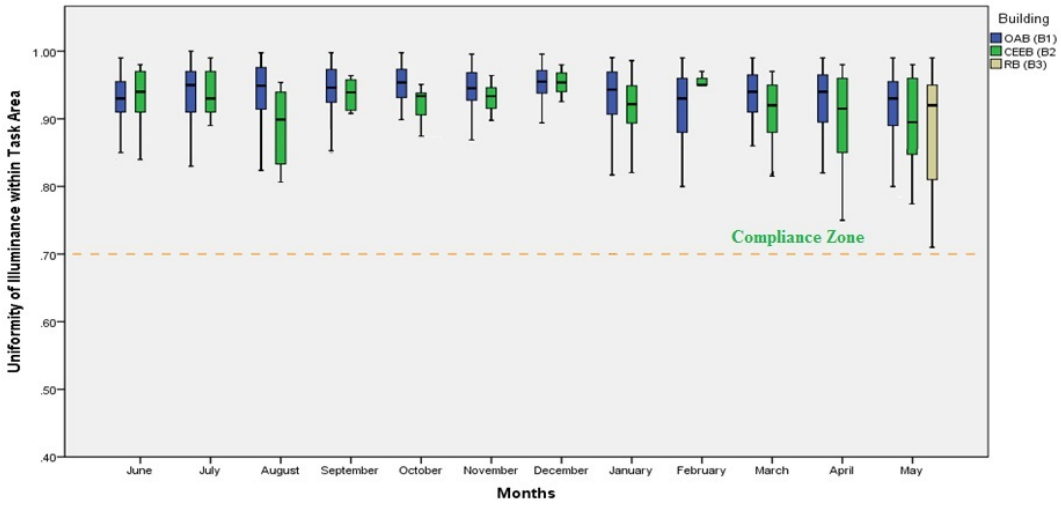
(b)

Figure 5.36 Location wise variations in (a) illuminance and (b) circadian light design for summer, monsoon and winter season in Chennai

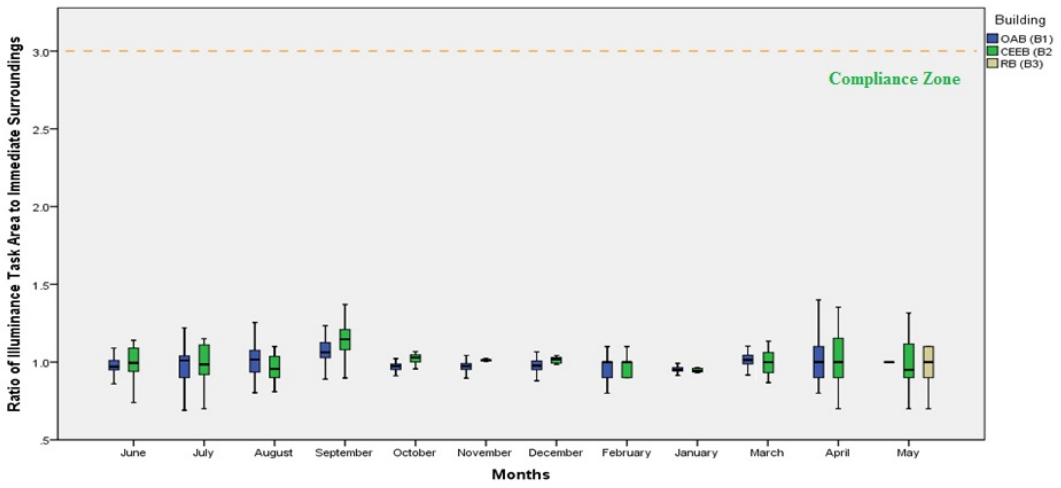
Figure 5.36 shows the location wise variation in illuminance and circadian light design for various seasons measured in Chennai. It was seen that the illuminance and circadian light design as higher in O2 where natural day light was employed. Also it was found that the values of illuminance and circadian light design in summer was highest and lowest in monsoon due to the overcast cloud cover during the later season.

5.4.3 Uniformity and Ratio of Task Area to Adjacent Surroundings

The distribution of light across the task area should be uninformed to attain the lighting comfort. The ratio of illuminance available in task area to the illuminance available in immediate adjacent surrounding (an area with a bandwidth of 0.5 m over the task area) should be within the threshold limits, as specified by ISHRAE IEQ standard. Also, the monthly variations of same are depicted in graphs as shown in Figure 5.37.



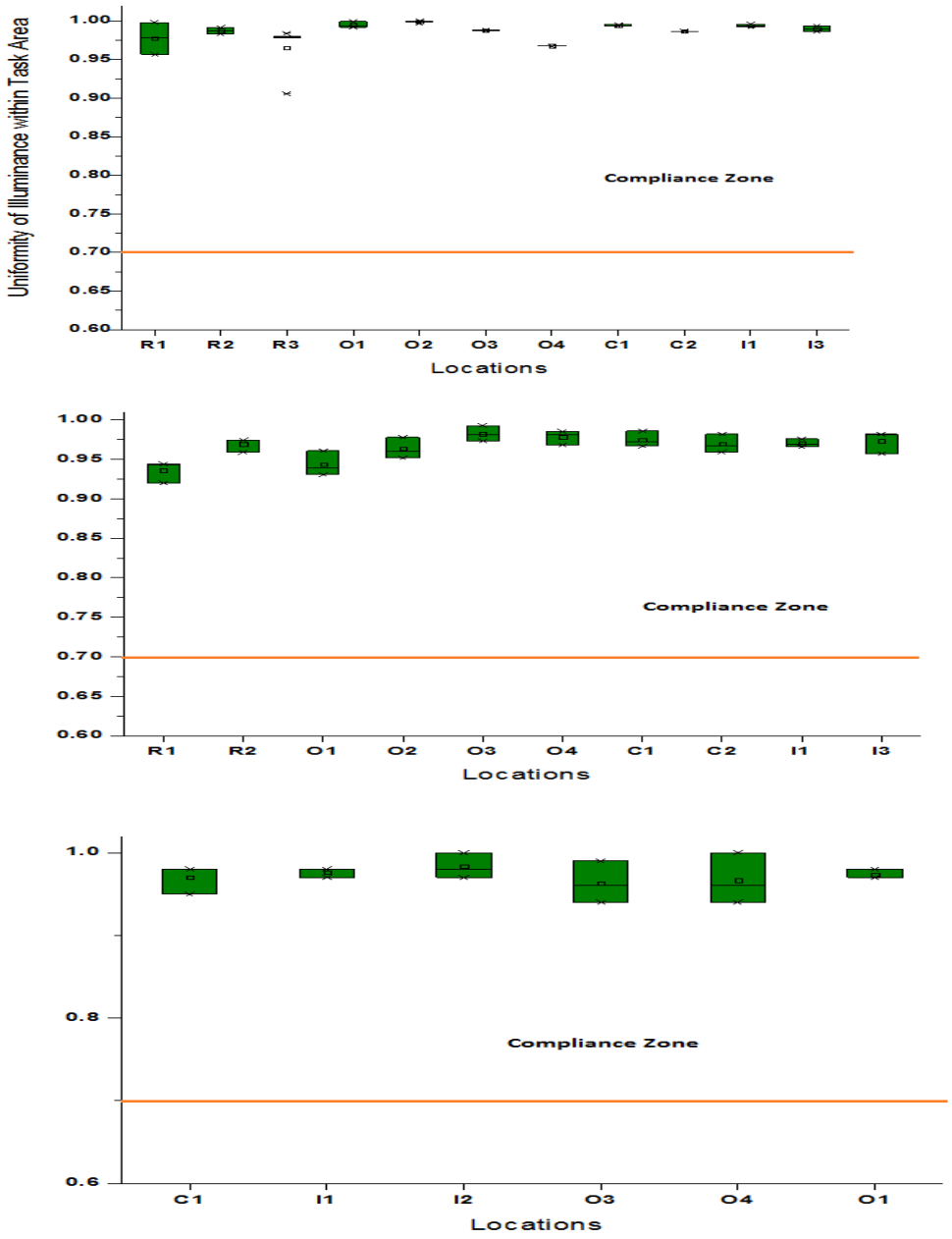
(a)



(b)

Figure 5.37 Monthly variation in (a) uniformity and (b) ratio of illuminance in Jaipur

Most of the times the values of uniformity of illuminance and ratio of illuminance of task area to immediately adjacent surroundings are found to be within the acceptable range. Further, the occupant location near to east and west facing windows are liable to have the high amount of direct sunlight causing inadmissible values of aforesaid parameters. As compared to immediately adjacent surroundings, the Lux obtained by occupant through task lighting is always observed to be high leading to lighting discomfort.



(a)

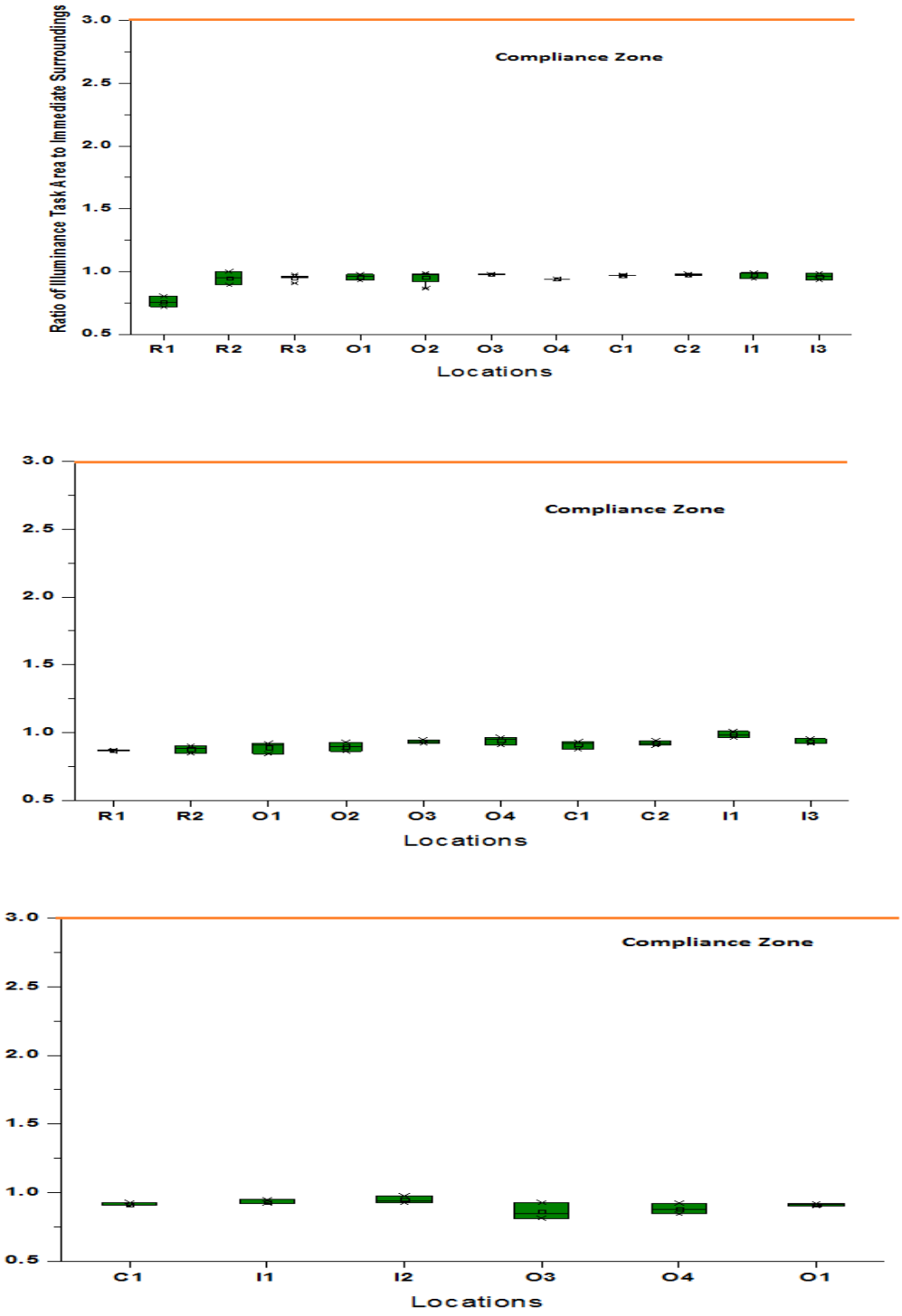


Figure 5.38 Location wise variation in (a) uniformity and (b) ratio of illuminance for summer, monsoon and winter respectively in Chennai

Figure 5.38 shows the location wise variation in uniformity of illuminance and ratio of illuminance for different seasons. It was seen that uniformity of illuminance and ratio of illuminance of task area to immediately adjacent surroundings were always within the acceptable range.

5.5 Acoustic Comfort

5.5.1 Overall Sound level

The acoustic discomfort occurs due to unwanted sound which causes stress, hearing loss, mental discomfort, after sleep patterns and affects heart rate. According to ISHRAE IEQ, the measurements related to acoustic comfort can be performed in terms of noise isolation class, reverberation time and noise criteria. In the present study, the overall sound level (dB) has been measured and analysed based on ASHRAE 62.1-2013. The monthly variations of overall sound level are shown in Figure 5.39.

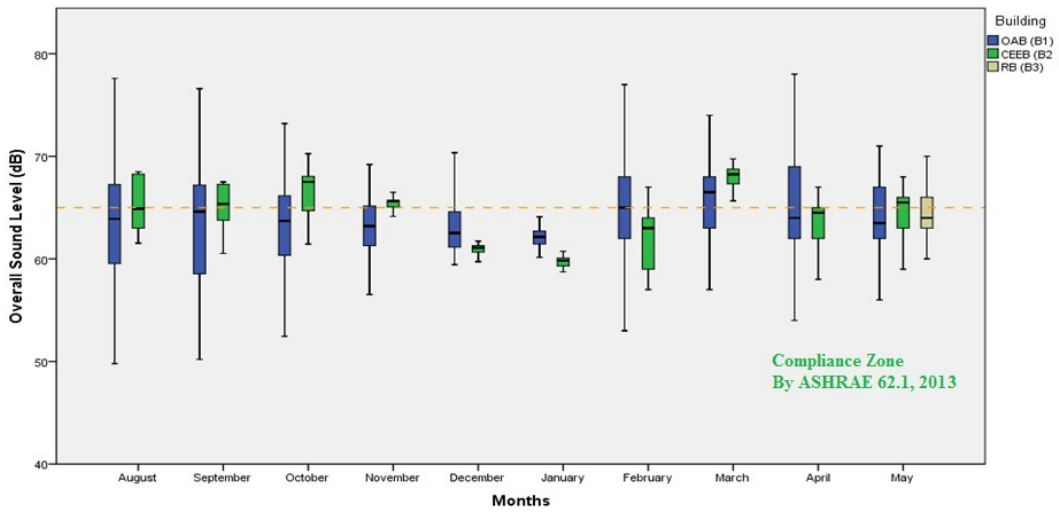


Figure 5.39 Monthly variations in overall sound level in Jaipur

The monthly mean of the overall sound level is reported to be within the limit as specified in ASHRAE 62.1-2013. Thus, the seasonal variations in the value of overall sound level are found insignificant. However, the major factors causing acoustic discomfort are observed due to chanting by the students in the classrooms and air flow sounds in the ducts and evaporative cooling systems. Sound levels in the month of January and May are observed minimum due to closing of classes on account of completion of the odd semester and even semester.

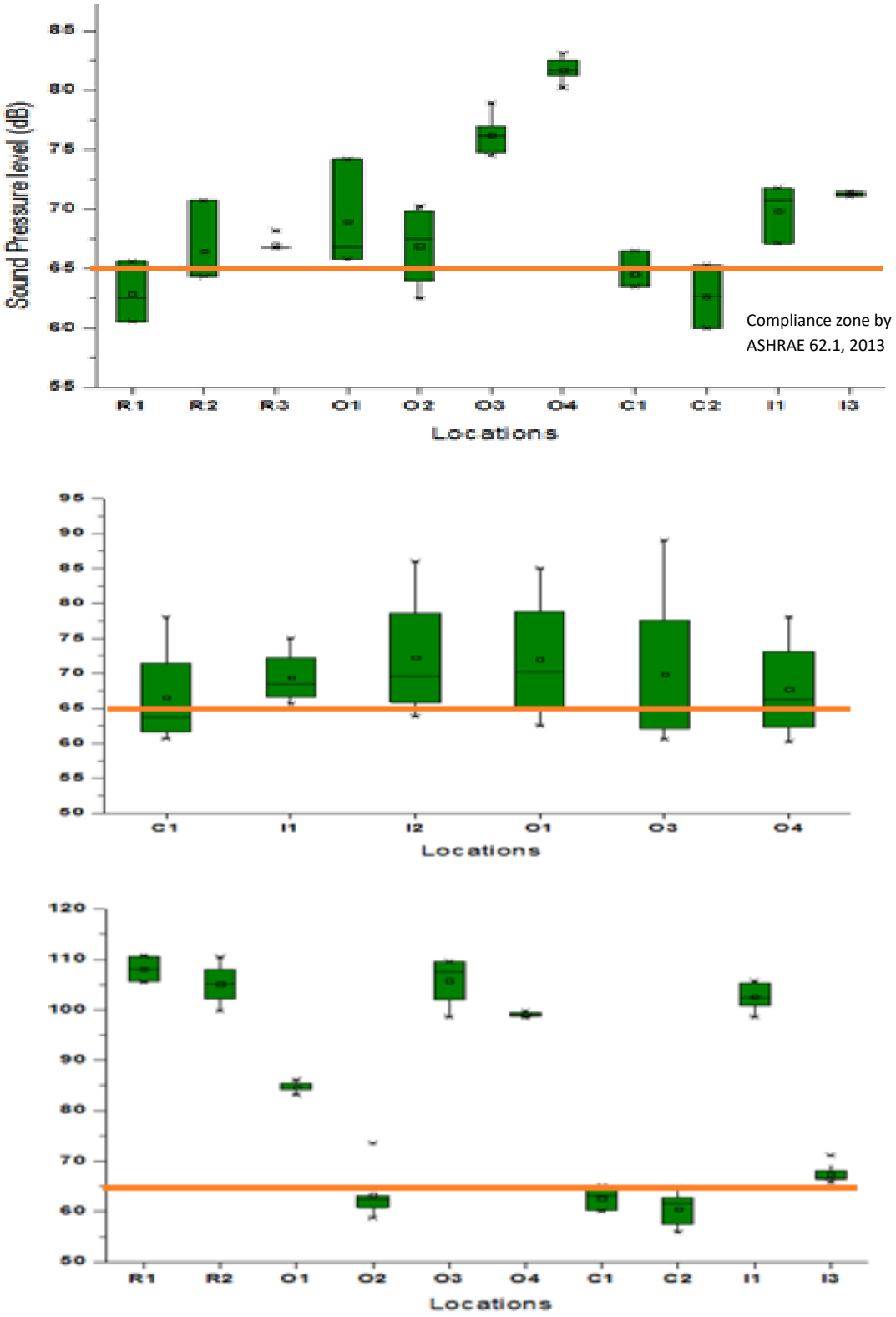


Figure 5.40 Location wise variations in sound pressure level for summer, monsoon and winter respectively in Chennai

Figure 5.40 shows the location wise variations in sound pressure level for different seasons measured in Chennai. The major factors causing acoustic discomfort are observed due to chanting by the students in Student office room air flow sounds in the ducts in office buildings and television sounds in residential buildings.

5.6 Occupant Satisfaction Survey

Subjective method is used to record the responses from occupants using a 7-point subjective scale for the given environment as specified in the ISHARE IEQ standard. Questionnaire is designed to record the various effects (sensation, comfort, preference, annoyance, stiffness and smell) to perform a subjective assessment of occupant comfort. Qualitative impact of parameters such as room temperature, RH, air flow, stale air, overall lighting, an external view and daylight availability are recorded in the questionnaire. The questionnaire is developed in such a way that all the responses can be recorded with easiness using a 7-point scale. Where it represents 1 as the worst unsatisfactory response and 7 as the best satisfactory response. Each parameter is represented in term of % satisfaction, where the response 1, 2 and 3 as unsatisfactory responses and 4, 5, 6 and 7 as a satisfactory response. Further, many other parameters such as gender, weight, age, height and native place representing occupant anonymity are also recorded in the same questionnaire, as suggested by (Dhaka et al., 2013). Overall IEQ occupant satisfaction for Buildings OAB, CEEB and the Residential building is found to be 83 %, 80 % and 81 % respectively. Monthly occupant satisfaction in Building OAB and CEEB are shown in Figure 5.41 and Figure 5.42 respectively.

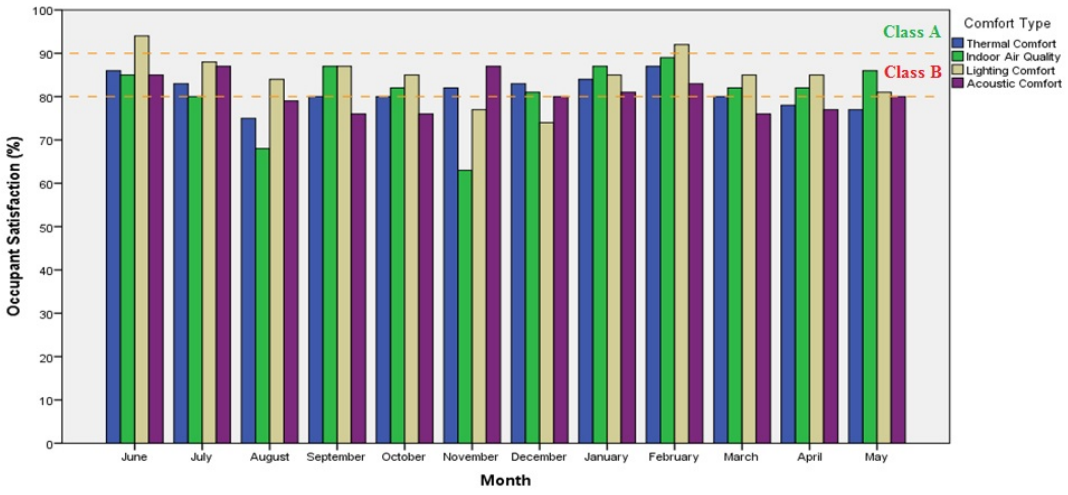


Figure 5.41 Monthly occupant satisfaction in Building OAB (Jaipur)

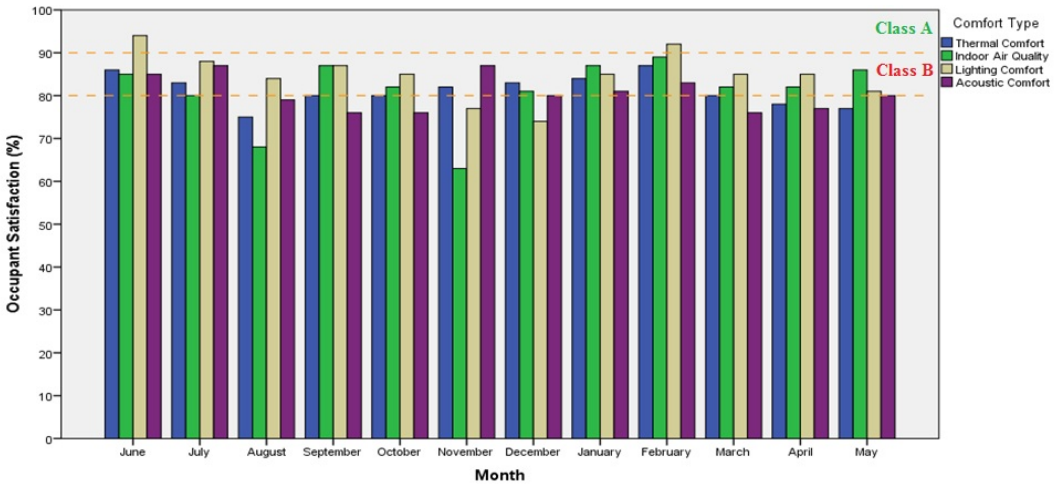
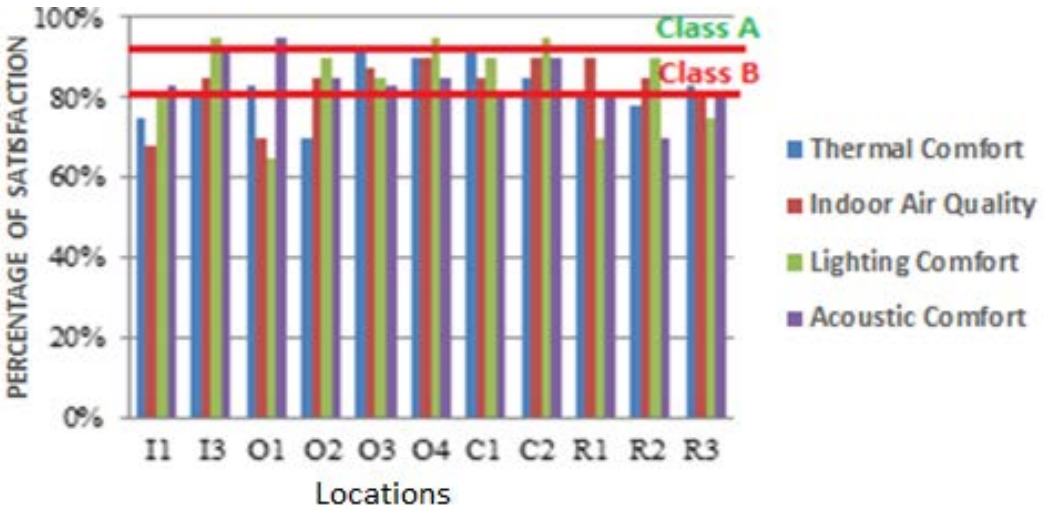


Figure 5.42 Monthly occupant satisfaction in Building CEEB (Jaipur)

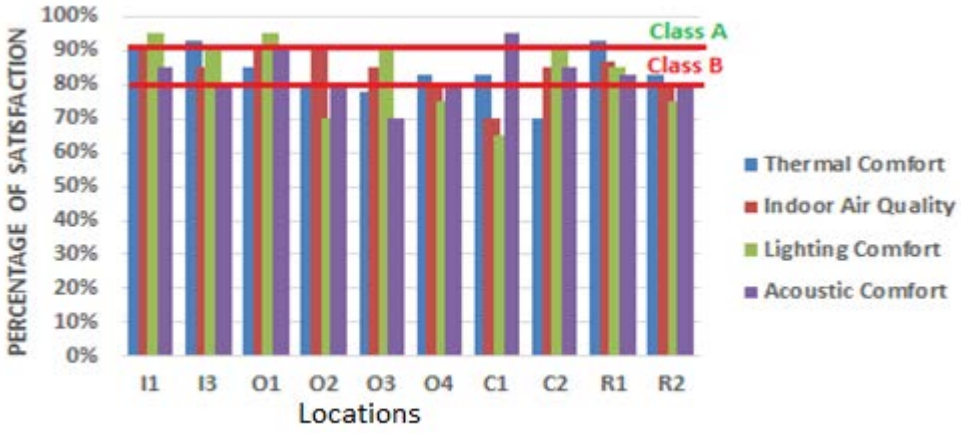
Occupant satisfaction in Residential Building are presented in Table 5.1

Occupant satisfaction survey results				
Building	**Threshold Value: A class=90%,B class=80%,C class= -**			
	Thermal Comfort	**Indoor Air Quality**	**Lighting Comfort**	**Acoustic Comfort**
Residential Building (B3)	68%	81%	80%	92%
Building Class	-	B	B	A

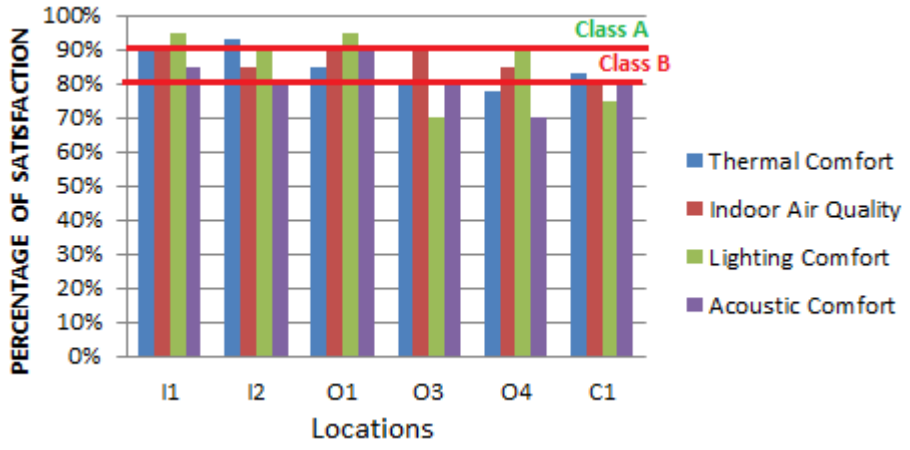
Table 5.1 Occupant satisfactions in Residential Building in Jaipur



(a)



(b)



(c)

Figure 5.43 Location wise occupant satisfaction for (a) summer, (b) monsoon and (c) winter season respectively in Chennai

Figure 5.43 shows the location wise variation in occupant satisfaction for different seasons surveyed in Chennai. The overall IEQ satisfaction expressed by the occupants for different buildings is given in Table 5.2

Monitoring Location	Overall IEQ Satisfaction
I1	86%
I3	88%
O1	86%
O2	81%
O3	83%
O4	83%
C1	82%
C2	86%
R1	84%
R2	81%
R3	80%

Table 5.2 Overall IEQ Occupant satisfactions recorded at different buildings in Chennai

CHAPTER 6

CONCLUSIONS AND FUTURE SCOPE

6.1 Conclusions

6.1.1 Instrumentation

- Considering the equipment availability and difficulty in finding equipment matching requirements specified in ISHRAE IEQ.
- As interim finding and recommendation, it is required to revisit the specifications mentioned in the standard, especially for IAQ parameter. Where the threshold value of any parameter is much higher as compared to the least count, the stringency of measurement may be considered especially for TVOC and CH_2O.
- Preferred measurement principle for IAQ instruments such as Gravimetric, Beta Attenuation, Gas Chromatography (GC) and FTIR sensor are not found in handheld instruments. However, the instruments for IAQ parameters should be portable and handheld instruments because the measurement methodology defined in ISHRAE IEQ standard is instantaneous or spot measurement.

6.1.2 Measurement Protocol

In this study, an investigation of IEQ parameters for two cities having a variety of building has been carried out under composite and warm-humid climate conditions and thus the concluding measurement methodology remarks drew are as follows:

- The study presents the importance of methods required for identification of a potential occupied location for the assessment of IEQ parameters and building performance.
- The overall approach for IEQ assessment (i.e. three times a day and once a month or twice a season at every potential occupant location) throughout a year is necessary to investigate the building characteristics.
- The methodology specified in the ISHARE IEQ standard, accepted for thermal comfort assessment in this study is appropriate.

- The measurement location specified in the ISHARE IEQ standard for IAQ parameters is suitable. In this study, the IAQ parameters are measured at each and every occupant location which is inappropriate because the standard deviation of IAQ parameters' values found within every room is observed to be low. Thus, the protocol for IAQ parameters measurement locations "All parameters should be measured at least one location in a room preferably as specified in Annexure B.1 in ISHARE IEQ standard" is correct.
- The measurement locations for SO_2, NO_2, and O_3 defined by ISHARE IEQ standard and same have been used in the present study is convenient. Further, SO_2, NO_2 and O_3 concentrations found at air intake are higher than indoor. Thus, the SO_2, NO_2 and O_3 concentrations measurement locations should be measured at least one location in a room preferably as specified in Annexure B.1 in ISHARE IEQ standard.
- Indoor and air intake comparison are necessary to find the source of contaminate.
- CO_2 concentrations should also be measured at ambient because of threshold values specified in ISHRAE IEQ standard as 'ambient + 350".
- The total microbial count should althe so be measured for both indoors and outdoors because of threshold values specified in ISHRAE IEQ standard is <ambient concentration.
- As lighting is the local phenomena and thus the parameters of lighting comfort are measured at occupant locations only. The methodology specified in the present study for lighting comfort assessment is appropriate.
- The occupant satisfaction survey along with physical parameter measurement is the most effective way for IEQ assessment
- The questionnaire specified in ISHRAE IEQ standard has required some revision such as thermal comfort questions should be for present instant instead of a specific season, questions for local discomfort, present activity and clothing should be added.

6.1.3 IEQ Assessment

- Most of the IEQ parameters are found to be meeting the minimum threshold limits for buildings in both climate zone.
- The acceptable range of comfort operative temperature can be increased at elevated air velocity. This method is relatively lower energy consumption to achieve the thermal comfort.
- The concentration of CO_2 obtained is falling in class A category, because of the high natural vegetation around the buildings which reduces the concentration of fresh air CO.
- In Jaipur, the concentration of respirable suspended particulate matter is found to be higher for the months from October to January. The concentrations of PM 2.5 for monsoon and summer season is within the acceptable range.
- Whereas in Chennai the indoor PM concentration was within the limits except when a strong indoor source is present. Also, the PM concentration was high in winter and lowest in monsoon.
- SO_2, NO_2, O_3, and CO concentrations are observed in a within the threshold range for both climatic regions. SO_2, NO_2 and CO concentrations found to be higher at air intake/ outdoor as compared to indoor levels because vehicles emissions are the major source. O_3 concentration is observed higher at air intake as compare indoor because of higher sunlight.
- The total microbial count in some locations were higher than the corresponding outdoor levels due to higher occupancy at these locations. Higher occupancy, inadequate ventilation and lack of maintenance activities in buildings can cause high total microbial concentration.
- The majority of lighting comfort parameters is found to be within the minimum threshold range.
- The LED light source consumes less energy as compare to other artificial light source but, the Lux and EML are found to be lower which causes the lighting discomfort and disturb the productivity as well as wellbeing of occupant.

- The occupant satisfaction survey along with physical parameter measurement is the most effective way for IEQ assessment. The occupant satisfaction level of more than 80% is calculated for all IEQ elements and for all buildings in both climatic zones.

6.2 Future Scope

The study investigation of IEQ parameters for two cities having a variety of building has been carried out under composite and warm-humid climate conditions. Further, the same investigation also is carried out at another climatic zone. Moreover, buildings other than university campus also be investigated throughout a year.

Parameters such as radiant temperature asymmetry and total microbial count are required to be investigated. Acoustic comfort parameters such as noise criteria, sound isolation class and reverberation time also are investigate to ensure the measurement methodology.

Erratum and addendum purposed in this study to be discussed and essential to add in the next version of ISHRAE IEQ standard. Further, based on the learning, improvements have to be made to increase the efficacy of the standard.

The reporting format and overall building evolution and rating using this standard need clarification and future work.

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ANNEXURE

A.1 IEQ Instrument Mater Sheet

Instruments Available in MNIT

Instrument Name	**Quantity**	**Measuring Parameters**	**Cost (Rs)**
Testo 480	05	**Thermal Comfort:** Air Temperature, MRT, Relative Humidity and Air Velocity **Lighting Comfort:** Illuminance **Indoor air Quality:** CO_2	5,00,000
Testo905-T2	01	**Thermal Comfort:** Floor Surface Temperature	6,840
Lutron LX103	02	**Lighting Comfort:** Illuminance	4,000
Lutron SL-4010	01	**Acoustic Comfort:** Sound Level	18,000

Indoor Air Quality parameters measuring instruments availability in the market

Instrument		Measuring Parameters	Comply (Y/N)	Quotation	
Manufacturer / Supplier	**Model Name**			**Availability**	**Cost (Rs)**
Applied Techno System Ltd	Handheld Air Quality Monitor	PM2.5 & PM10	Y	2-3 Week	1,48,000
	Portable VOC Monitor in PID	TVOC	Y	2-3 Week	58,000
	ATS 103M	CO,CH2O,SO2,NO2	N	2-3 Week	1,71,500
	ATS 103M	O3	N	2-3 Week	86,000
GRAYWOLF / Mecord Systems & Services Pvt. Ltd.	Modular Area Mnitor	Display for Probe TG501 & IQ610		4-6 Week	2,70,000
	TG-501	CO,SO2,NO2,O3,O2	N	4-6 Week	2,66,000
	IQ-610	VOC,RH,Temp,CO2,CO	Y	4-6 Week	3,74,000
	GW3016A	PM2.5 & PM10	N	4-6 Week	4,28,000
	FM 801	CH2O	N	4-6 Week	1,62,000
UNIPHOS	299PM-PID	TVOC	N	4 Week	85200
	SS-500-100B// DT-500-1A	TVOC	N	4 Week	98,000
	298PM	CH2O	N	4 Week	45,050
	SS-500-098A//DT-500-1A	CH2O	N	4 Week	60,600
	240PM	SO2	N	4 Week	29,100
	SS-500-040A//DT-500-1A	SO2	N	4 Week	44,650
	281PM	NO2	N	4 Week	29,100
	SS-500-081A//DT-500-	NO2	N	4 Week	44,650

Instrument		Measuring Parameters	Comply (Y/N)	Quotation	
Manufacturer / Supplier	**Model Name**			**Availability**	**Cost (Rs)**
	1A				
	SS-500-015A//DT-500-1A	O3	N	4 Week	57,500
BRMC	BR-HOL-1210	PM2.5,PM10,CHOH,RH,Temp	N	6-8 Weeks	61,213
	BR-AIR-329	PM2.5,TVOC,Temp	N	6-8 Weeks	12,374
	BR-AIR-300	(PM2.5,CHOH,Temp)	N	6-8 Weeks	11,374
	BR-SMART-126	PM2.5,PM10,CHOH,TVOC	N	6-8 Weeks	64,757
Xi'an Yima Opto-electrical Technology Co., Ltd.	1080-A professional	PM2.5,PM10,CHOH,SO2,NO2,O3	N	8 Weeks	37,28,675
ION Science / Swan Scientific LLP New Delhi	TIGER	TVOC		6-8 Weeks	475000
PPM Technology Ltd. / SWAN Environmental Pvt. Ltd.	Formaldemeter™ htV-M	CH2O	N	4 weeks	2,52,000
Kilter Ozone Analyzer	O3 Meter KT-2006	O3	N	5 weeks	78634
2B technology/ Entrol Systems Corporation	Personal Ozone Monitor™ (POM™)	O3	Y	8 to 10 weeks	3,48,800

A.2 Observations and clarifications on measurement

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
Measurement Methodology			
Overall Measurement approach	Once a Month in all three seasons (Summer, Winter, Monsoon)	1. Once a month in all three seasons (Summer, Winter, Monsoon)	Thrice a day covers all climatic change occurring in a day during a day
		2. Three times a day (10.00 AM, 02.00 PM, 04.30 PM) 3. One Room per Day	
Thermal comfort measurement approach	1. Air temp & average air speed shall be measured at sitting position (0.1m, 0.6m, 1.1m) and standing position (0.1m, 1.1m, 1.7m)	1. Air temp & average air speed shall be measured at sitting position (0.1m, 0.6m, 1.1m) and standing position (0.1m, 1.1m, 1.7m)	
	2. Operative temperature (avg. of MRT and RAT) shall be measured at 0.6m and 1.1 m for seating and standing position	2. Operative temperature (avg. of MRT and RAT) shall be measured at 0.6m and 1.1 m for seating and standing position respectively	

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
	respectively		
Measurement Methodology of Indoor air quality	1. Will be measured at least one location per floor and wing or in one location for each set of rooms with same activity	1. All indoor air quality parameters will be measured at occupant's location.	1. For subjective analysis value of indoor air quality parameters measured at the occupant's location
	2. CO, SO2, NO2, O3, PM2.5, PM10, CH2O, CO2 will be measure at air intake of the room (AHU air intake or air vent or open window)	2. CO, SO2, NO2, O3 will be measure at air intake of the room (AHU air intake or air vent or open window)	2. Outside environment air may also be a source of indoor CO, SO2, NO2, and O3.
	3. Total Microbial Count will be measured at least one location per floor and wing or in one location for each set of rooms with same activity	3. Total Microbial Count will be measured at one most critical location per floor and only once in a season	3 There is no instrument available for on the spot measurement of microbial count. Samples need to be taken for lab testing.
Measurement Methodology of lighting comfort			
1. Task area	Not specified	The partial area in the workplace	Reference: EN 12464-1:2002 /3.2/5

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
		in which the visual task is carried out. For places where the size and/or location of the task area is unknown, the area where the task may occur shall be taken as the task area	
3. % of task area meeting the required illuminance	Not specified	Percentage of the task area meeting the required illuminance	Percentage of number of workstations meeting the required illuminance out of total number of workstations
4. How to find Correlated Color Temperature (CCT)	Not specified	Note down the type, make, model of light source	In the brochure of model of light source we can find the CCT
Measurement Methodology of Acoustic comfort			
1. Assessment method to for reverberation time	ISO 3380-2	Once in whole period of measurement	
Occupant Satisfaction Survey Form		Appropriate response based on your general satisfaction (Not specific to any time)	
1. Occupant Name		Disclosure of identity is optional	
2. Gender			
3. Weight	Not specified	To find body surface area by Dubois formula for thermal comfort analysis	Reference: ASHRAE Standard 55 - 2013

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
4. Age of Occupant	Not specified		
5. Height of the Occupant	Not specified	To find body surface area by Dubois formula for thermal comfort analysis	Reference: ASHRAE Standard 55 - 2013
6. Native place of Occupant	Not specified	An acclimatization analysis for thermal comfort	
7. Occupant's residing years in present city	Not specified	An acclimatization analysis for thermal comfort	
8.Survey Questions as specified in IEQ standard 2016-2017			
Indoor Environment Quality Surveyor Form 1 (to be filled at occupant's location)			
1. Location of Project (City)			To find the climatic condition of city
2. Date & Time			To find outdoor climatic condition at specific date and time instant by weather station
3. Building Name			To find directional position
4. Building Type			Commercial/Residential/Mixed
			and

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
			Naturally Ventilated/ Air Conditioned/Mixed
5. Occupant Location Code			As per the location identified in building plan e.g. B1F1R1S1 Where 'B' building code, 'F' Floor code, 'R' Room code, S seat code
Thermal Comfort measurements			
6. Outdoor Temperature at the Location		At specific date and time instant by weather station	Find relation between indoor and outdoor temperature condition for thermal comfort analysis
7. Relative Humidity at Occupant's working position (in %, at height of 0.6 m for sitting and 1.1 m for standing position)	As specified in standard		For thermal comfort analysis
8. Mean Radiant Temperature at Occupant's working position (in degree Celsius, at height of 0.6 m for sitting and 1.1 m for standing position)	As specified in standard		To find operative temperature for thermal comfort analysis
9. Air Velocity at 0.1 m	As specified in standard		To find average velocity, velocity

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
height at all four points (0.1m, 0.6m, 1.1m, 1.7m) separately			difference and velocity gradient
10. Room air Temperature at 0.1 m height at all four points (0.1m, 0.6m, 1.1m, 1.7m) separately	As specified in standard		1. To find Operative temperature at height of 0.6 m for sitting and 1.1 m for standing position
			2. To vertical temperature difference
11. Floor Surface Temperature	As specified in standard		To find local thermal discomfort due to hot or cold floor
12. Plane Radiant Temperature asymmetry	As specified in standard		To find local thermal discomfort due to Radiant Temperature asymmetry
Indoor Air Quality Measurements			
13. Concentration of CO2,CO,PM2.5, PM10, TVOC, CH2O, SO2, NO2, O3		To be filled at occupant's location	For subjective analysis it is necessary to have both aspects: how is occupant feeling and what instrument is measuring.
Lighting Comfort Measurements			

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
14. Illuminance of task area at left, right, mid sections separately			1. To find Average Illuminance of task Area
			2. For calculate Uniformity of Illuminance
15. Illuminance of immediately adjacent surroundings at left, right and mid portion separately			To find Illuminance of immediately adjacent surroundings to calculating the ratio between task area and immediately adjacent surrounding
Section of lighting comfort fill only when more than one sources of lighting are used			To find EML for different light source separately
			e.g. EML= EML(source 1)+EML(source2)
Only source one is switched ON (lighting source e.g. day-light, CFL, LED etc.)			
16. Illuminance of task area at left, right, mid section separately			To find Average Illuminance of task Area
17. Lighting source type, make, Model			To find CCT (In the brochure of model of light source)
Only source two is switched ON (lighting source e.g.			

Problems	Statement of IEQ standard 2016-2017	Solution	Reason/Reference
day-light, CFL, LED etc.)			
18. Illuminance of task area at left, right, mid-section separately			To find Average Illuminance of task Area
19. Lighting source type, make, Model			To find CCT (In the brochure of model of light source)
Acoustic Comfort Measurements			
20. Sound pressure level (in dB) at frequency 62.5 Hz,125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz			To calculate Noise criteron

Indoor Environment Quality Surveyor Form 3			
1. Concentration of CO_2,CO,PM2.5, PM10, TVOC, CH_2O, SO_2, NO_2, O_3		CO, SO_2, NO_2, O_3, PM2.5, PM10, CH_2O, CO_2 will be measure at air intake of the room (AHU air intake or air vent or open window)	Outside environment air may also a source of indoor CO, SO2, NO2, O3, PM2.5, PM10, CH2O, CO2
2. Concentration of Total microbial count		Measure at one most critical location per floor and only once in a season	There is no portable as well as real-time measurement instrument available for on the spot measurement of microbial count. Samples need to be taken for lab testing.
3. Reverberation Time		measure only once in all season at every room	Reverberation Time does not change with respect to season, climatic condition and day time

A.3 Selection of buildings and measurement locations

Building-1: Old Administration Building, MNIT Jaipur

For measurement of IEQ parameters the first building selected is Old Administration Building, MNIT Jaipur. This building is situated in an area with rich natural vegetation, away from heavy traffic and covers a **total area of 2000 square meters distributed over3 floors, having 25 rooms, and offer 66 types of potential occupant locations**. This includes Individual offices, shared offices, laboratories and Classrooms in which some are naturally ventilated and other are air-conditioned. The building code for Old Administration Building, MNIT Jaipur is **B1**.

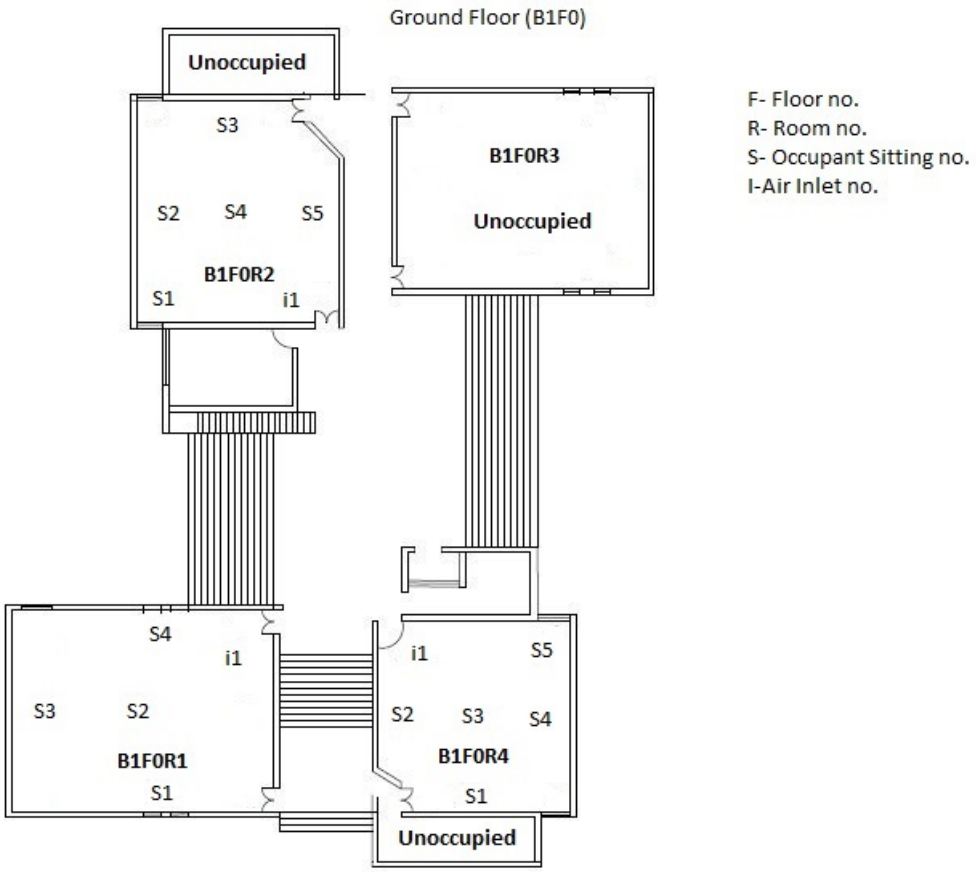
Nomenclature of Building and Occupant Location:

Occupant location code is specified in the form of four letters, each followed by a number e.g. **B1F2R5S3**. The nomenclature used is explained below:

Place	Code	Examples
Building	B	B1,B2,B3 etc.
Floor	F	F-1for Underground, F0 for ground floor, F2 second floor, F3 third floor etc.
Room	R	R1,R2,R3 etc.
Occupant Location	S	S1,S2,S3,S4 etc.
Air Inlet	I	I1,I2,I3,I4 etc.

a. Ground Floor (B1F0)

Location Plan



Room Code (Utility / Type)	Seating Code	Reason
B1F0R1 (Class room/ naturally ventilated)	S1	Near the closed glass window
	S2	Center of the room
	S3	Below the light source and fan
	S4	Near the closed glass window
B1F0R2 (Class room/ naturally ventilated)	S1	Near the closed glass window
	S2	Away from doors and window. under fan
	S3	Below the light source and fan
	S4	Center of the room
	S5	Away from doors and window. under fan
B1F0R3 (Unoccupied)		
B1F0R4 (Class room/ naturally ventilated)	S1	Below the light source and fan
	S2	Away from doors and window.

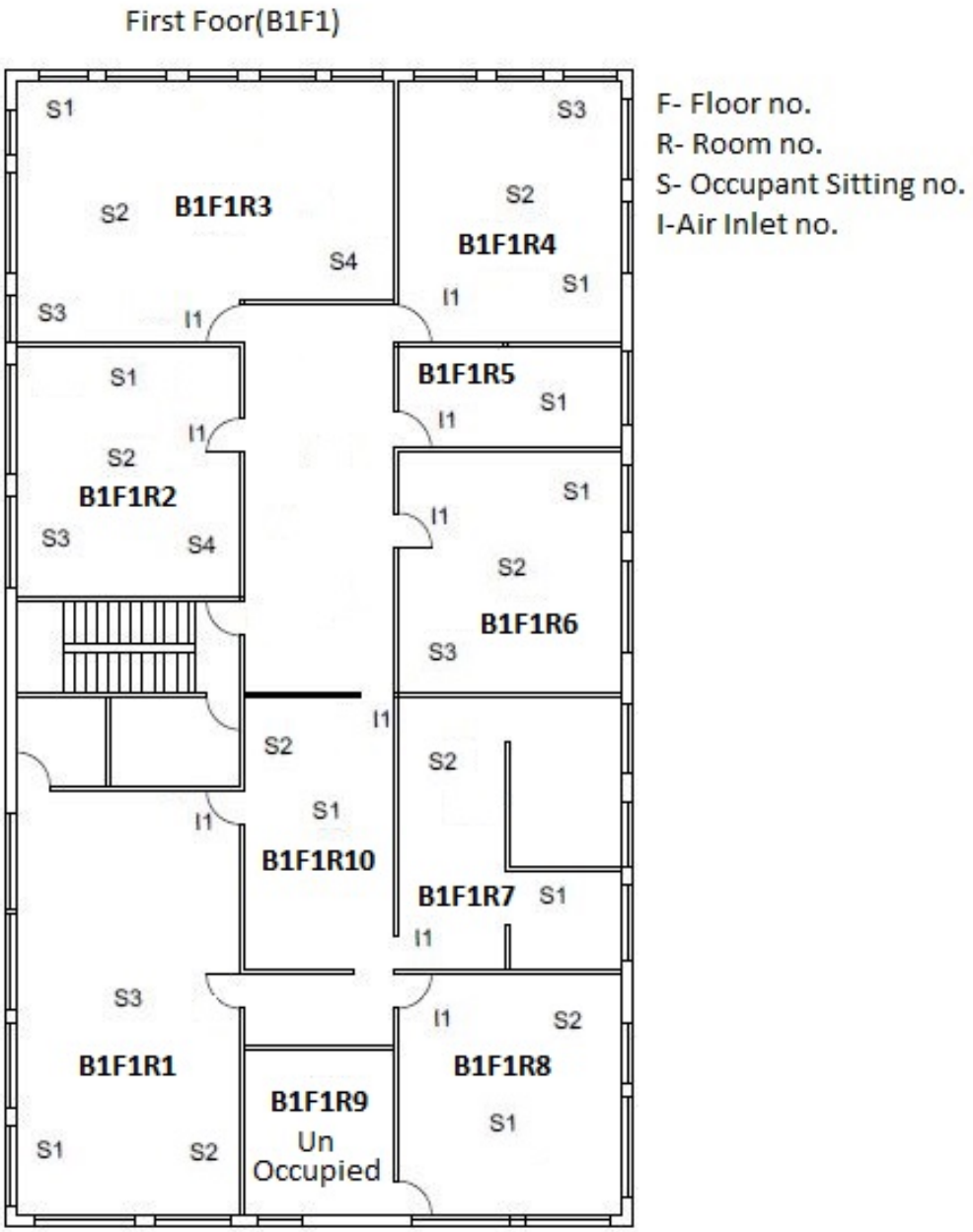
Room Code (Utility / Type)	Seating Code	Reason
		under fan
	S3	Center of the room
	S4	Away from doors and window. under fan
	S5	Near the closed glass window

Details of Inlet air sources

Room Code	Air inlet source Code	Reason
B1F0R1	I1	Open door
B1F0R2	I1	Open door
B1F0R3(Unoccupied)	--	--
B1F0R4	I1	Open door

b. 1st Floor (B1F1)

Location Plan



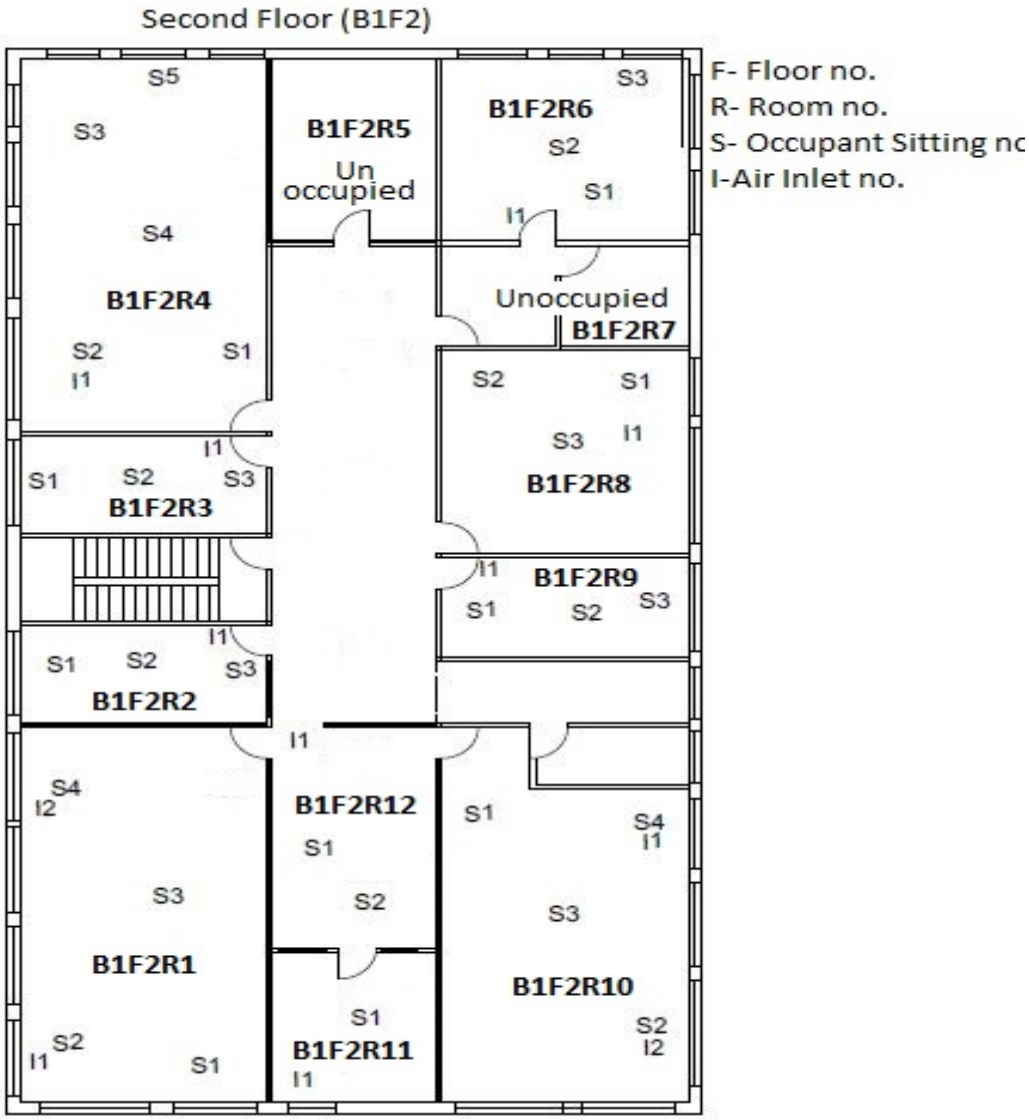
Room Code(Utility)	**Seating Code**	**Reason**
B1F1R1 (conference hall / Air conditioned)	S1	Near the closed glass window with curtains
	S2	Away from doors and window, near to the Air conditioner
	S3	Center of the room
B1F1R2 (shared office/ Air conditioned)	S1	Near to the Air conditioner
	S2	Center of the room
	S3	Near the closed glass window with curtains
	S4	Away from doors and window
B1F1R3 (combined two class room/ Air conditioned)	S1	Near the closed glass window
	S2	Center of the room
	S3	Near the closed glass window
	S4	Away from doors and window
B1F1R4(shared office/ Air conditioned)	S1	Below the AC and light source and near to closed window with curtains
	S2	Center of room
	S3	near to closed window with curtains
B1F1R5 (individual office/ Air conditioned)	S1	Below the AC and light source and near to closed window with curtains
B1F1R6 (shared office/ Air conditioned)	S1	Below the AC and light source and near to closed window with curtains
	S2	Center of room
	S3	Below the AC and light source
B1F1R7 (shared office/ Air conditioned)	S1	Small individual cabin, Below the AC and light source and near to closed window with curtains
	S2	Shared cabin, aluminium glass partition with R10 below the fan and light source
B1F1R8 (individual office/ Air conditioned)	S1	Center of room
	S2	Below the AC
B1F1R9 (store)		Unoccupied Room
B1F1R10 (Waiting room/ Air conditioned)	S1	Below the AC
	S2	Center of room and under fan

Details of Inlet air sources

Room Code	Air inlet source Code	Reason
R1	I1	Open door
R2	I1	Open door
R3	I1	Open door
R4	I1	Open door
R5	I1	Open door
R6	I1	Open door
R7	I1	Open door
R8	I1	Open door
R9		Unoccupied Room
R10	I1	Open door

c. 2nd Floor (B1F2)

Location Plan



Room Code(Utility)	**Seating Code**	**Reason**
BIF2R1 (Laboratory/ Air conditioned)	S1	Near to closed glass window
	S2	Near to evaporative cooler
	S3	Center of the room
	S4	Near to the evaporative cooler
B1F2R2(shared office/ Air conditioned)	S1	Near to close glass window & AC
	S2	Center of the room
	S3	Near to close glass door and window
B1F2R3(individual office/ Air conditioned)	S1	Near to close glass window & AC
	S2	Center of the room
	S3	Away from AC and window
B1F2R4(Laboratory/ Air conditioned)	S1	Near to closed glass door and Aluminum glass partitioned wall
	S2	Below the radiant cooling duct
	S3	Below the radiant cooling duct and near closed glass window
	S4	Center of the room
	S5	Near to close glass window
B1F2R5		Unoccupied room
B1F2R6(shared office/ Air conditioned)	S1	Below the AC
	S2	Center of the room
	S3	Near closed glass window
B1F2R7		Unoccupied room
B1F2R8(Laboratory/ Air conditioned)	S1	Near to closed glass window
	S2	Away from window and door, below the fan
	S3	Center of the room and near to 2 stage evaporative cooler
B1F2R9(Laboratory/ Air conditioned)	S1	Away from window and AC
	S2	Center of the room and below the AC
	S3	Near to closed glass window
B1F2R10 (shared office/ Air conditioned)	S1	Near to aluminum glass partition
	S2	Near to evaporative cooler
	S3	Center of the room
	S4	Near to evaporative cooler
B1F2R11(shared office/ Air conditioned)	S1	Center of the room and below the fan
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	Waiting lobby, below the fan
	S2	Away from fan below the lighting source

Details Inlet air sources

Room Code	**Air inlet source Code**	**Reason**

B1F2R1	I1	In front of Evaporative Cooler
	I2	In front of Evaporative Cooler
B1F2R2	I1	Open door
B1F2R3	I1	Open door
B1F2R4	I1	In front of radiant cooling inlet air duct
B1F2R5		Unoccupied room
B1F2R6	I1	Open door
B1F2R7		Unoccupied room
B1F2R8	I1	In front of two stage Evaporative Cooler
B1F2R9	I1	Open door
B1F2R10	I1	In front of Evaporative Cooler
	I2	In front of Evaporative Cooler
B1F2R11	I1	Open door
B1F2R12	I1	Open door

2. Building-2: Centre for Energy and Environment Building, MNIT Jaipur

For measurement of IEQ parameters the second building selected is Centre for Energy and Environment Building, MNIT Jaipur. This building is situated in an area **nearer (around 65 meters) to the roadway covers a total area of 162 square meters having 1 floor, 3 rooms, and 10 types of potential occupant locations.** This includes shared offices, laboratories in which some are naturally ventilated and others are air conditioned. The building code for Centre for Energy and Environment Building, MNIT Jaipur is B2.

a. Ground Floor (B2F0)

Location Plan

Room Code (Utility / Type)	Seating Code	Reason
B2F0R1 (shared office/ Air conditioned)	S1	Near the closed glass window, Exposed wall from both sides and the nearest window is towards the roadway
	S2	Center of the room
	S3	Away from doors, near to Air conditioner and window
B2F0R2 (Laboratory, shared office / Mixed conditioned)	S1	Near the closed glass window, below the fan and light source
	S2	Center of the room
	S3	Near the closed glass window, below the fan and light source. The nearest window is towards the roadway
	S4	Near the window and evaporative cooler
B2F0R3 (shared office/ Air conditioned)	S1	Near the closed glass window, below the light source. The nearest window is towards the roadway
	S2	Center of the room
	S3	Near to Air conditioner and window

Details of Inlet air sources

Room Code	Air inlet source Code	Reason
B2F0R1	I1	Open door
B2F0R2	I1	Evaporative Cooler
B2F0R3	I1	Open door

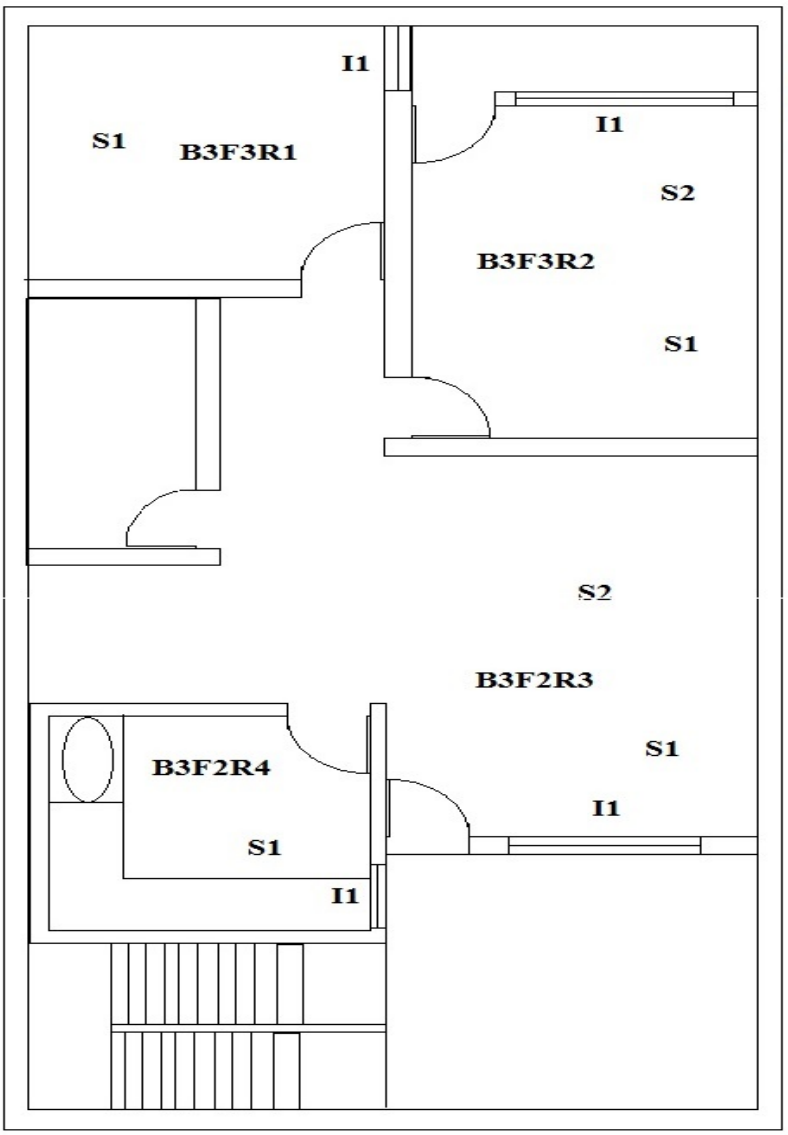
3. Building-3: Residential building (B3) Jaipur

For measurement of IEQ parameters the third building selected is a residential apartment Building at Jaipur. This building is situated in highly dense urban area having 3 floors only third floor is used for measurement, covers a total area of 125 square meters, 2 Bedrooms, 1 Livingroom and 1 Kitchen and 6 types of potential occupant locations. The building code for this Building is **B3**.

Third Floor (B3F3)

Location Plan

Residenrial Building (B3F3)



Room Code (Utility / Type)	Seating Code	Reason
B3F3R1 (Bedroom 1/ Naturally ventilated)	S1	Center of the room
B3F3R2 (Bedroom 2 / Naturally ventilated)	S1	One side of bed, away the closed window, below the fan and light source
	S2	One side of bed Near the closed window, below the fan and light source
B3F3R3(Livingroom/ Air-conditioned)	S1	Near to Evaporative Cooler and window
	S2	Center of the room, below the fan and light source
B3F3R4 (Kitchen Naturally ventilated)	S1	Center of the room

Details of Inlet air sources

Room Code	Air inlet source Code	Reason
B3F3R1	I1	Open Window
B3F3R2	I1	Open Window
B3F3R3	I1	Evaporative Cooler
B3F3R4	I1	Open Window

A.4 Occupant satisfaction survey and IEQ measurement forms

1. Occupant Satisfaction Survey Form

(Please fill your most appropriate response based on your general satisfaction (Not specific to any time)

1. Name
(Disclosure of identity is optional)

_____

2. Gender
Mark only one oval.

- ◯ Female
- ◯ Male

3. Weight (
In Kg)

_____

4. Age of Occupant (
in years)

_____

5. Height of the Occupant
(in feet and inches e.g. 5 ft 7 inches simply write 5.07)

_____

6. Native place of Occupant

_____

7. Occupant's residing years in present city *Mark only one oval.*

- ◯ <1
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ >3

8. Rate your satisfaction with temperature conditions of your normal work area in summer *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

9. Rate your satisfaction with temperature conditions of your normal work area in monsoon *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

10. Rate your satisfaction with temperature conditions of your normal work area in winter *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

11. Rate your satisfaction with air movement available to you in your normal work area *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

12. Rate your satisfaction with overall humidity in your normal work area *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

13. Rate your satisfaction with overall air quality in your normal work area (Stuffiness, staleness, smell)
Mark only one oval.

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

14. My work area's layout enables me to work without unwanted noise interruptions *Mark only one oval.*

	1	2	3	4	5	6	7	
Disagree	◯	◯	◯	◯	◯	◯	◯	Agree

15. My normal work area provides adequate sound privacy (not being overheard by other)
Mark only one oval.

	1	2	3	4	5	6	7	
Disagree	◯	◯	◯	◯	◯	◯	◯	Agree

16. Rate your satisfaction with overall noise in your normal work area *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

17. Rate your satisfaction with overall lighting comfort in your normal work area (e.g. amount of light, glare, reflections, contrast)
Mark only one oval.

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

18. Rate your satisfaction with external view from your normal work area *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

19. Rate your satisfaction with access to daylight from your normal work area *Mark only one oval.*

	1	2	3	4	5	6	7	
Unsatisfactory	◯	◯	◯	◯	◯	◯	◯	Satisfactory

2. Indoor Environment Quality Surveyor Form

(to be filled at occupant's location)

1. Surveyor Name:

2. Occupant Name:

3. Location of Project (City)

4. Date

Example: December 15, 2012

5. Time

Example: 8:30 AM

6. Building Name

7. Building Type

Mark only one oval per row.

	Naturally Ventilated	Air Conditioned	Mixed Mode
Commercial			
Residential			
Mixed			

8. Occupant Location Code

(As per the location identified in building plan)

Thermal Comfort measurements

9. Outdoor Temperature at the Location (in degree Celsius upto first decimal place)

10. Relative Humidity at Occupant's working position
(in %, at height of 0.6 m for sitting and 1.1 m for standing position)

11. Mean Radiant Temperature at Occupant's working position
(in degree Celsius, at height of 0.6 m for sitting and 1.1 m for standing position)

12. Air Velocity at 0.1 m height:
(in m/s)

13. Air Velocity at 0.6 m height:
(in m/s)

14. Air Velocity at 1.1 m height:
(in m/s)

15. Air Velocity at 1.7 m height:
(in m/s)

16. Room Air Temperature at 0.1 m height: (in degree Celsius)

17. Room Air Temperature at 0.6 m height: (in degree Celsius)

18. Room Air Temperature at 1.1 m height: (in degree Celsius)

19. Room Air Temperature at 1.7 m height: (in degree Celsius)

20. Floor Surface Temperature (in degree Celsius)

21. Plane Radiant Temperature asymmetry (in degree Celsius)

Indoor Air Quality Measurements

22. Concentration of CO2 (in ppm)

23. Concentration of CO (in ppm)

24. Concentration of PM 2.5 (in µg/m3)

25. Concentration of PM 10 (in µg/m3)

26. Concentration of TVOC (in ppm)

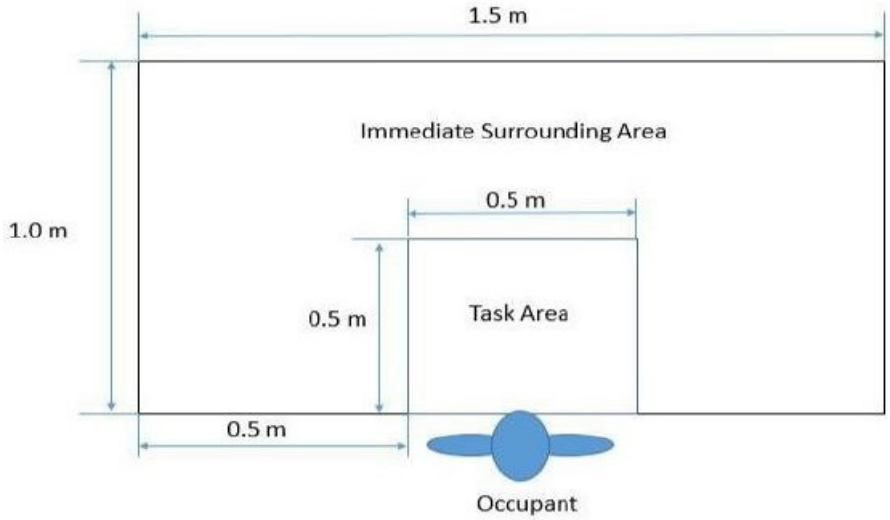
27. Concentration of CH2O (in ppm)

28. Concentration of SO2 (in ppm)

29. Concentration of NO2 (in ppm)

30. Concentration of O3 (in ppm)

Lighting Comfort Measurements



31. Illuminance at left side of task area (in lux)

32. Illuminance at right side of task area (in lux)

33. Illuminance at mid section of task area (in lux)

34. Illuminance of left portion of immediately adjacent surroundings (in lux)

35. Illuminance of right portion of immediately adjacent surroundings (in lux)

36. Illuminance of middle portion of immediately adjacent surroundings (in lux)

Below Section of lighting comfort fill only when more than one sources of lighting are used

(lighting source e.g. day-light, CFL, LED etc.)

Only source one is switched ON

37. Illuminance at left side of task area (in Lux)

38. Illuminance at right side of task area (in Lux)

39. Illuminance at mid section of task area (in Lux)

40. Lighting source type
(e.g. day-light, CFL, LED etc.)

41. Lighting source make

42. Lighting source model

Only source two is switched ON

(lighting source e.g. day-light, CFL, LED etc.)

43. Illuminance at left side of task area (in Lux)

44. Illuminance at right side of task area (in Lux)

45. Illuminance at mid section of task area (in Lux)

46. Lighting source type
(e.g. day-light, CFL, LED etc.)

47. Lighting source make

48. Lighting source model

Acoustic Comfort Measurements

49. Noise Criteria
(in dB)

50. Overall sound pressure (in
dB)

Measure once in total measurement period

51. Reverberation Time
(in dB)

3. Indoor Environment Quality Surveyor Form

(to be filled at air inlet)

1. Surveyor Name:

2. Date

Example: December 15, 2012

3. Time

Example: 8:30 AM

4. Room Location Code
(e.g. B1F1R2)

5. Concentration of SO2 (
in ppm)

6. Concentration of NO2 (
in ppm)

7. Concentration of O3 (
in ppm)

8. Concentration of CO (
in ppm)

9. Concentration of CO2 (
in ppm)

10. Concentration of PM2.5 (
in µg/m3)

11. Concentration of PM10 (in µg/m3)

12. Concentration of CH2O (in ppm)

13. Concentration of Total microbial count (in CFU/m3; measure at one most critical location per floor and only once in a season)

A.5 Summary of measurements and results

1. Results of June, 2017 (Summer)

a. Old Administration Building, MNIT Jaipur

Measurement taken from 12th June, 2017 to 22nd June, 2017

Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort				
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Blue	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31 <C	Not specified	Ambient+350/Ambient+500/Ambient+700	<15/<25/<25		at least 250 EMLis present within at leat 75% of work station/not for class C	0.7/0.7/-	3:1/-/-	Threshold Value: A class=90%,B class=80%,C class= -
Room Code (Utility/ type)	Seating Code	Ambient Temperature(<C)	Operative temperature(<C)	RH(%)	Floor surface temperature(<C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance
BIF2R1 (Laboratory/ Air conditioned)	S1	36.9	33.0	59	32.8	0.48	381	23	626	664	0.84	1.19	
	S2	36.9	28.9	68	33.8	0.91	392	23	404	428	0.93	1.18	
	S3	36.9	31.0	58	32.5	0.65	416	17	423	448	0.91	0.99	
	S4	36.9	30.6	56	31.3	0.69	392	17	401	425	0.93	0.99	75
B1F2R2(shared office/ Air conditioned)	S1	35.7	26.2	53	26.1	0.71	633	22	398	422	0.91	1.01	
	S2	35.7	23.3	47	29.1	0.25	620	21	271	287	0.89	1	50
B1F2R3(individual office/ Air conditioned)	S1	31.8	27.3	43	30.0	0.23	701	10	327	347	0.98	0.95	
	S2	31.8	27.5	39	30.1	0.16	493	8	359	381	0.95	1.07	0
B1F2R4(Laboratory/ Air conditioned)	S1	31.8	27.2	44	32.1	0.12	428	10	337	357	0.96	0.89	
	S2	31.8	27.9	42	32.7	0.14	435	10	342	362	0.91	0.98	
	S3	31.8	27.6	43	32.3	0.12	435	11	260	276	0.89	0.97	
	S4	31.8	28.2	44	32.1	0.18	445	8	134	142	0.98	0.99	50
B1F2R6(shared office/ Air conditioned)	S1	31.4	27.2	48	28.5	0.26	550	12	222	235	0.95	0.87	
	S2	31.4	28.1	51	28.9	0.20	528	9	223	236	0.91	0.92	
	S3	31.4	28.7	53	29.7	0.24	582	10	258	274	0.91	0.86	0
B1F2R8(Laboratory/ Air conditioned)	S1	35.1	28.9	62	29.8	0.96	456	9	259	275	0.85	1.01	
	S2	35.1	27.8	67	30.0	0.28	434	15	339	359	0.94	0.96	
	S3	35.1	27.1	68	28.7	0.56	400	9	355	376	0.87	0.97	67
B1F2R9(Laboratory/ Air conditioned)	S1	31.8	26.6	42	27.9	0.30	609	8	345	366	0.99	1.01	
	S2	31.8	25.1	51	25.4	0.86	628	11	311	330	0.93	0.94	100
B1F2R10 (shared office/ Mixed mode conditioned)	S1	36.4	33.2	50	35.9	0.48	391	23	369	391	0.98	1.09	
	S2	36.4	33.1	51	36.0	1.66	400	25	539	571	0.93	1.08	
	S3	36.4	33.0	51	36.0	0.51	395	24	424	449	0.94	1.01	
	S4	36.4	33.6	49	36.1	2.01	416	26	353	374	0.92	0.97	100
B1F2R11(shared office/ Air conditioned)	S4	38.8	30.9	66	32.6	1.96	381	22	363	385	0.96	0.95	100
B1F2R12 (Waiting lobby/ naturally	S1	34.5	33.0	57	33.8	1.13	405	23	130	138	0.95	0.97	
	S2	34.5	33.1	56	33.8	0.80	412	23	125	133	0.97	0.96	0

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
Old Admin Block (B1)	86%	85%	94%	85%
Building Class	B	B	A	B

b. Centre for Energy and Environment Building, MNIT Jaipur

Measurement taken on 23rd June, 2017

Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort				
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Blue	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31	Not specified	Ambient+350/Ambient+500/Ambient+700	<15/<25/<25		at least 250 EMLis present within at leat 75% of work station/not for class C	0.7/0.7/-	3:1/-/-	A class=90%,B class=80%,C class=80%
Room Code (Utility / Type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance
B2F0R1 (shared office/ Air conditioned)	S1	33.8	29.4	46	29.9	1.08	582	18	210	223	0.9	0.74	
	S2	33.8	23.2	44	30.1	0.54	535	17	312	331	0.98	1.08	
	S3	33.8	28.6	48	29.4	0.57	612	18	374	396	0.84	0.93	67
B2F0R2 (Laboratory, shared office / Mixed mode	S1	33.8	33.1	58	33	0.62	469	21	245	260	0.95	0.94	
	S2	33.8	32.2	58	32.5	0.77	459	23	229	243	0.94	0.98	
	S3	33.8	31.9	54	32.2	0.98	513	20	292	309	0.97	1.14	
	S4	33.8	31.3	66	31.6	1.44	466	21	371	393	0.94	1.13	25
B2F0R3 (shared office/ Air conditioned)	S1	33.8	30.9	48	31.7	1.37	503	19	268	284	0.92	1.01	
	S2	33.8	30.9	50	30.7	0.47	588	18	279	296	0.97	1.09	
	S3	33.8	29.5	50	30.3	1.43	620	18	290	307	0.91	0.94	0

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	84%	78%	74%	71%
Building Class	B	-	-	-

2. Results of July, 2017 (Monsoon)

a. Old Administration Building, MNIT Jaipur

Measurement taken from 24th July, 2017 to 31st July, 2017

Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort				
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	**threshold value**	**Not specified**	**24.5+-2.5°C**	**30-70%**	**A class 17-31°C only**	**Not specifie**	**Ambient+350/Ambient+500/Ambient+700**	**A class=15, B class=25, C class=25**		**at least 250 EMLis present within at leat 75% of work station/not for class C**	**A class=0.7, B class= 0.7, C class= -**	**A class=3:1, B class= -, C class= -**	**Threshold Value: A class=90%,B class=80%,C class= -**
Room Code (Utility/ type)	**Seating Code**	**Ambient Temperature(°C)**	**Operative temperature(°C)**	**RH(%)**	**Floor surface temperature(°C)**	**Air velocity(m/s)**	**CO2(ppm)**	**PM2.5(ug/m3)**	**Illuminance (Lux)**	**Circadian Lighting Design (EML)**	**Uniformity of Illuminance within task area**	**ratio of illuminance task area to immediate surroundings**	**Percentage of the task area meeting the required illuminance**
BIF2R1 (Laboratory/ Air conditioned)	**S1**	30.5	29.5	82	27.6	0.29	356	31	441	452	0.87	1.19	
	S2	30.5	29.5	82	29.0	0.90	355	34	617	642	0.83	0.74	
	S3	30.5	29.8	80	29.3	0.65	378	32	291	301	0.96	1.04	
	S4	30.5	29.4	84	29.6	0.73	366	35	427	443	0.97	1.01	75
B1F2R2(shared office/ Air conditioned)	**S1**	27.2	25.5	69	26.5	0.52	618	14	380	406	0.81	0.93	
	S2	27.2	27	72	28.2	0.29	576	11	172	180	0.95	1.1	50
B1F2R3(individual office/ Air conditioned)	**S1**	27.2	26.5	66	27.5	0.33	664	12	282	292	0.93	1.01	
	S2	27.2	25.6	72	27.6	0.18	665	12	283	291	0.86	1	0
B1F2R4(Laboratory/ Air conditioned)	**S1**	30	28.7	65	28.7	0.12	393	24	298	366	0.99	0.94	
	S2	30	28.9	61	29.0	0.15	394	29	500	518	0.93	1.06	
	S3	30	28.1	56	29.1	0.18	378	26	396	325	0.95	0.88	
	S4	30	28.5	60	28.5	0.40	390	27	330	436	0.97	0.97	75
B1F2R6(shared office/ Air conditioned)	**S1**	31.5	29.1	61	27.5	0.23	498	16	295	304	0.91	1.01	
	S2	31.5	27.8	66	27.5	0.21	508	18	250	270	0.95	0.88	
	S3	31.5	27.8	69	28.0	0.20	530	18	384	387	0.91	1.01	0
B1F2R8(Laboratory/ Air conditioned)	**S1**	27.2	27.4	94	27.4	0.33	441	20	388	424	0.98	1.09	
	S2	27.2	27.3	93	27.4	1.31	456	19	445	464	0.97	0.91	
	S3	27.2	27.1	94	27.3	0.32	420	22	272	286	0.84	0.87	67
B1F2R9(Laboratory/ Air conditioned)	**S1**	30.5	20.3	61	23.7	0.91	669	17	314	322	0.91	0.9	
	S2	30.5	24.6	49	26.6	0.61	513	15	350	363	0.9	1.16	100
B1F2R10 (shared office/ Mixed mode conditioned)	**S1**	31.5	31.8	72	31.7	0.36	427	20	413	427	0.97	1.22	
	S2	31.5	31.8	73	31.4	2.05	406	21	445	446	0.81	0.83	
	S3	31.5	31.5	72	31.3	0.32	416	18	567	598	0.94	1.19	
	S4	31.5	31.6	73	31.3	1.89	410	20	389	414	0.99	1.03	100
B1F2R11(shared office/ Air conditioned)	**S4**	30.5	30.2	79	30.6	1.16	417	31	378	392	0.97	0.95	100
B1F2R12 (Waiting lobby/ naturally ventilated)	**S1**	30	31.5	71	31.5	0.94	387	37	136	138	0.97	1.03	
	S2	30	31.6	70	31.4	0.51	385	38	138	166	0.96	1.02	0

		Thermal Comfort					Indoor air quality		lighting comfort				
Color Code: **A Class: Green** **B Class: Purple** **C Class: Red** **Out of any class: Red**	**threshold value**	**Not specified**	**24.5+-2.5°C**	**30-70%**	**A class 17-31°C only**	**Not specified**	**Ambient+350/Ambient+500/Ambient+700**	**A class=15, B class=25, C class=25**		**at least 250 EMLis present within at leat 75% of work station/not for class C**	**A class=0.7, B class= 0.7, C class= -**	**A class=3:1, B class= -, C class= -**	**A class=90%,B class=80%,C class= 80%**
Room Code (Utility / Type)	**Seating code**	**Ambient Temperature(°C)**	**Operative temperature(°C)**	**RH(%)**	**Floor surface temperature(°C)**	**Air velocity(m/s)**	**CO2(ppm)**	**PM2.5(ug/m**	**Illuminance (Lux)**	**Circadian Lighting Design (EML)**	**Uniformity of Illuminance within task area**	**Ratio of illuminance task area to immediate surroundings**	**Percentage of the task area meeting the required illuminance**
FIRST FLOOR													
B1F1R2 (shared office/ Air conditioned)	**S1**	29.7	26.5	64	26.4	0.25	959	30	189	203	0.99	0.9	
	S2	29.7	26.6	64	27.3	0.52	957	30	195	212	0.95	0.85	
	S3	29.7	26.9	65	27.4	0.41	1010	30	248	267	0.99	1.32	0
B1F1R3 (combined two class room/ Air conditioned)	**S1**	29.7	27.9	84	28.3	0.50	853	34	150	164	1	0.75	
	S2	29.7	28.5	76	28.5	1.41	794	36	117	134	0.92	1.04	
	S3	29.7	28.3	82	28.5	0.41	817	35	290	308	0.93	1.21	
	S4	29.7	27.4	84	28.1	0.38	993	33	73	91	0.94	0.69	0
B1F1R4(shared office/ Air conditioned)	**S1**	29.7	25.7	70	26.0	0.72	683	30	205	166	0.99	1.01	
	S2	29.7	25.9	73	26.4	0.33	702	31	237	188	0.99	1.04	0
B1F1R6 (shared office/ Air conditioned)	**S1**	29.7	26.1	64	26.1	0.16	701	32	457	470	0.97	0.94	
	S2	29.7	26.6	65	25.9	1.36	647	30	152	162	0.85	1.57	50
B1F1R7 (shared office/ Air conditioned)	**S1**	29.7	28.6	74	28.2	0.81	833	32	164	184	0.91	1.06	
	S2	29.7	29.1	74	29.1	0.77	834	32	163	184	0.97	1.09	0
B1F1R8 (individual office/ Air conditioned)	**S1**	29.7	26.7	61	27.2	0.14	613	25	409	429	0.93	0.92	100
B1F1R10 (Waiting room/ Air conditioned)	**S1**	29.7	28.4	75	28.2	0.36	847	32	97	112	0.93	0.85	
	S2	29.7	28.5	74	28.5	0.97	830	36	86	103	0.95	0.95	0

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	79%	76%	84%	83%
Building Class	**-**	**-**	**B**	**B**

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b. Centre for Energy and Environment Building, MNIT Jaipur

Measurement taken on 18th July, 2017

Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort				
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class=15, B class=25, C class=25		at least 250 EMLis present within at leat 75% of work station/not for class C	A class=0.7, B class= 0.7, C class= -	A class=3:1, B class= -, C class= -	A class=90%,B class=80%,C class= 80%
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance
B2F0R1 (shared office/ Air conditioned)	S1	32.1	29.3	67	29.6	0.89	528	23	240	252	0.89	0.7	
	S2	32.1	29.1	68	29.8	0.86	553	25	341	364	0.99	1.08	
	S3	32.1	28.5	68	29.0	0.61	484	24	306	316	0.76	0.84	67
B2F0R2 (Laboratory, shared office / Mixed mode	S1	32.1	31.7	67	31.9	0.49	499	23	180	185	0.93	0.96	
	S2	32.1	31.7	68	32.0	0.78	452	24	215	223	0.93	0.95	
	S3	32.1	31.8	68	32.0	0.57	445	23	249	260	0.97	1.15	
	S4	32.1	31.4	68	32.0	1.52	460	22	376	389	0.97	1.12	25
B2F0R3 (shared office/ Air conditioned)	S1	32.1	30.1	65	30.4	1.08	502	23	207	214	0.91	1.01	
	S2	32.1	30.1	64	30.4	0.86	522	21	249	262	0.97	1.11	
	S3	32.1	29.8	65	30.7	1.18	520	23	293	305	0.91	0.92	0

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	86%	83%	77%	81%
Building Class	B	B	-	B

3. Results of August, 2017 (Monsoon Season)

a) Old Administration Building, MNIT Jaipur

Measurement taken from 22nd August, 2017 to 31st August, 2017

		Thermal Comfort					Indoor air quality		lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class=15, B class=25, C class=25		at least 250 EMLis present within at leat 75% of work station/not for class C	A class=0.7, B class= 0.7, C class= -	A class=3:1, B class= -, C class= -	Threshold Value: A class=90%,B class=80%,C class= -	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
BIF2R1 (Laboratory/ Air conditioned)	S1	33.69	33.5	65	33.8	0.62	340	32	505	519	0.94	1.1	100	64
	S2	33.69	33.4	64	33.5	1.79	338	34	434	449	0.91	1.0		67
	S3	33.69	33.6	65	33.8	1.16	347	33	438	464	0.99	1.0		70
	S4	33.69	33.2	65	33.6	0.61	366	36	421	436	0.95	1.0		69
B1F2R2(shared office/ Air conditioned)	S1	30.28	27.1	66	27.6	0.35	754	23	405	433	0.90	0.9	50	60
	S2	30.28	27.4	72	28.1	0.32	767	27	174	183	0.94	1.0		59
B1F2R3(individual office/ Air conditioned)	S1	28.28	27.7	64	28.0	0.19	470	24	317	269	0.99	1.1	100	53
	S2	28.28	27.1	63	28.3	0.21	476	26	313	281	0.95	1.1		54
B1F2R4(Laboratory/ Air conditioned)	S1	28.28	28.0	64	28.4	0.24	499	25	281	320	0.98	1.0	75	63
	S2	28.28	27.7	63	28.2	0.25	483	22	623	379	0.94	1.1		64
	S3	28.28	27.7	63	27.9	0.27	476	22	629	304	0.98	1.0		64
	S4	28.28	27.4	63	28.2	0.23	444	23	319	242	0.92	1.1		63
B1F2R6(shared office/ Air conditioned)	S1	29.96	28.0	64	28.7	0.32	584	34	247	243	0.94	1.2	0	63
	S2	29.96	27.9	63	28.6	0.24	695	33	228	244	0.99	0.9		65
	S3	29.96	27.4	63	28.5	0.21	650	31	212	186	0.95	1.0		58
B1F2R8(Laboratory/ Air conditioned)	S1	29.96	28.8	83	30.0	0.22	470	41	308	335	0.98	1.5	100	60
	S2	29.96	29.9	79	30.4	0.54	495	40	344	353	0.85	0.9		66
	S3	29.96	30.2	79	30.3	0.34	468	39	237	248	0.96	0.9		62
B1F2R9(Laboratory/ Air conditioned)	S1	30.28	27.0	65	28.2	0.47	777	31	367	381	0.90	1.1	100	57
	S2	30.28	26.7	68	28.2	0.57	926	28	324	334	0.98	0.9		58
B1F2R10 (shared office/ Mixed mode conditioned)	S1	33.69	33.8	65	34.0	0.39	358	31	391	404	0.96	1.2	75	65
	S2	33.69	33.6	65	34.1	2.06	377	33	398	414	0.89	1.0		66
	S3	33.69	33.4	66	33.9	0.40	357	29	424	442	0.97	1.0		66
	S4	33.69	33.6	65	33.8	1.34	376	30	283	297	0.94	1.1		68
B1F2R11(shared office/ Air conditioned)	S1	30.28	29.0	86	30.5	0.26	523	38	341	351	0.91	0.9	100	69
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	30.28	30.3	84	30.7	0.72	457	39	148	157	0.98	1.1	0	68
	S2	30.28	29.7	83	30.3	1.06	433	35	143	150	0.98	1.0		68

FIRST FLOOR														
B1F1R1 (Conference room/ Air conditioned)	**S1**	29.28	27.1	55	29.8	1.18	403	22	286	285	0.91	1.3	67	62
	S2	29.28	27.3	57	28.2	1.05	404	27	383	383	0.78	1.4		64
	S3	29.28	27.5	57	28.6	0.67	382	23	344	344	0.97	0.9		68
B1F1R3 (combined two class room/ Air conditioned)	**S1**	29.28	29.3	86	29.4	0.73	407	35	194	193	0.99	1.0	25	66
	S2	29.28	29.6	79	28.4	1.89	404	35	124	120	0.97	0.8		67
	S3	29.28	29.5	79	29.4	1.23	413	34	373	379	0.87	1.0		66
	S4	29.28	27.5	84	28.5	0.41	412	36	144	142	0.75	1.1		50
B1F1R4(shared office/ Air conditioned)	**S1**	29.28	26.5	67	27.1	0.35	413	27	345	350	0.91	1.1	100	50
	S2	29.28	26.8	69	27.6	0.75	421	26	336	341	0.94	0.7		53
B1F1R6 (shared office/ Air conditioned)	**S1**	29.28	27.1	61	26.2	0.21	438	26	486	497	0.97	0.8	100	52
	S2	29.28	28.1	58	27.5	0.27	424	26	348	352	0.84	1.3		51
B1F1R7 (shared office/ Air conditioned)	**S1**	29.28	28.9	72	28.6	0.93	650	31	172	169	0.92	1.1	0	55
	S2	29.28	29.1	73	29.6	0.71	660	31	170	167	0.97	1.1		56
B1F1R8 (individual office/ Air conditioned)	**S1**	29.28	28.7	74	28.7	0.30	638	31	305	320	0.94	0.9	100	58
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	29.28	29.8	77	29.8	0.75	385	38	105	101	0.93	1.0	0	61
	S2	29.28	29.6	77	29.9	1.03	376	35	95	90	0.98	0.9		64
Ground Floor														
B1F0R1 (Classroom / naturally ventilated)	**S1**	29.52	29.0	75	29.1	0.36	849	13	202	209	0.77	1.0	0	68
	S2	29.52	29.0	75	29.0	0.47	853	16	170	176	0.93	1.0		67
	S3	29.52	28.8	81	29.1	0.42	860	14	148	154	0.98	0.8		64
	S4	29.52	29.0	76	28.9	1.45	845	17	155	161	0.97	1.0		72
B1F0R2 (Classroom / naturally ventilated)	**S1**	29.52	29.3	78	29.2	0.42	1050	19	287	298	0.89	0.9	75	64
	S2	29.52	29.1	80	29.1	0.33	1011	21	559	581	0.99	1.0		66
	S3	29.52	29.3	79	29.2	0.37	1037	20	440	458	0.97	1.0		62
	S4	29.52	29.2	79	29.2	0.23	1032	20	556	578	0.98	1.0		62
B1F0R4 (Classroom / naturally ventilated)	**S1**	29.52	28.9	77	29.6	0.21	650	21	281	292	1.00	0.9	25	70
	S2	29.52	28.9	76	29.1	0.31	895	25	267	277	0.94	1.1		77
	S3	29.52	29.0	76	29.0	0.74	866	20	376	390	0.96	1.0		72
	S4	29.52	28.9	76	29.1	0.39	855	19	239	248	0.82	1.4		78

Occupant satisfaction survey results				
Building	**Threshold Value: A class=90%,B class=80%,C class= -**			
	Thermal Comfort	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	71%	64%	80%	75%
Building Class	**-**	**-**	**B**	

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 18th August, 2017

Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class=15, B class=25, C class=25		at least 250 EMLis present within at leat 75% of work station/not for class C	A class=0.7, B class= 0.7, C class= -	A class=3:1, B class= -, C class= -	A class=90%,B class=80%,C class= 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	34.19	28.3	45	29.4	0.75	560	27	240	254	0.82	0.9	33	65
	S2	34.19	28.1	44	28.7	0.54	577	26	292	310	0.87	1.1		63
	S3	34.19	27.5	44	28.8	0.30	586	22	321	333	0.83	0.9		62
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	34.19	34.0	50	32.5	0.47	507	26	190	195	0.94	1.0	0	68
	S2	34.19	33.5	50	34.1	0.47	476	29	254	263	0.89	0.9		69
	S3	34.19	33.7	50	34.0	0.72	484	30	238	247	0.94	1.0		68
	S4	34.19	32.1	51	33.6	1.18	470	30	272	279	0.92	1.0		66
B2F0R3 (shared office/ Air conditioned)	S1	34.19	29.5	53	31.3	0.30	512	27	311	328	0.81	0.9	67	63
	S2	34.19	30.6	50	31.5	1.52	490	31	394	422	0.95	1.1		64
	S3	34.19	30.7	49	32.5	1.52	488	32	289	297	0.91	0.8		65

Occupant satisfaction survey results				
Building	Threshold Value: A class=90%,B class=80%,C class= -			
	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	80%	83%	61%	82%
Building Class	B	B	-	B

4. Results of September, 2017 (Post-Monsoon Season)

a) Old Administration Building, MNIT Jaipur

- Measurement taken from 22nd September, 2017 to 28th September, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class=15, B class=25, C class=25		at least 250 EMLis present within at leat 75% of work station/not for class C	A class=0.7, B class= 0.7, C class= -	A class=3:1, B class= -, C class= -	Threshold Value: A class=90%,B class=80%,C class= -	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
BIF2R1 (Laboratory/ Air conditioned)	S1	33.4	32.6	51	33.1	0.64	412	30	468	481	0.94	1.1	100	65
	S2	33.4	32.5	51	32.6	1.07	410	32	483	494	0.92	1.1		68
	S3	33.4	32.3	51	32.9	1.35	411	31	479	508	0.96	1.0		71
	S4	33.4	32.3	51	32.9	1.24	407	31	451	469	0.96	1.0		70
B1F2R2(shared office/ Air conditioned)	S1	33.1	26.7	45	27.1	0.66	466	20	368	392	0.94	1.1	50	58
	S2	33.1	27.0	45	28.9	0.23	562	20	174	183	0.93	1.0		57
B1F2R3(individual office/ Air conditioned)	S1	33.1	26.7	45	27.1	0.66	466	19	368	392	0.94	1.1	100	51
	S2	33.1	27.0	45	28.9	0.23	562	18	174	183	0.93	1.0		56
B1F2R4(Laboratory/ Air conditioned)	S1	32.2	29.7	53	30.6	0.12	448	20	403	429	0.97	1.1	75	65
	S2	32.2	29.5	53	30.6	0.17	437	20	298	310	0.96	1.0		66
	S3	32.2	29.2	58	30.3	0.08	408	17	551	598	0.92	1.1		66
	S4	32.2	29.7	52	30.3	0.16	447	19	538	577	0.96	1.0		65
B1F2R6(shared office/ Air conditioned)	S1	32.2	29.2	52	30.3	0.34	533	21	315	328	0.86	1.1	100	62
	S2	32.2	29.3	52	30.3	0.35	548	17	249	267	0.94	1.0		64
	S3	32.2	29.1	51	30.4	0.28	564	18	338	322	0.95	1.2		57
B1F2R8(Laboratory/ Air conditioned)	S1	32.2	29.0	68	30.7	0.22	412	26	447	482	0.81	1.2	100	59
	S2	32.2	29.0	69	29.5	0.71	411	29	501	526	0.88	1.2		67
	S3	32.2	29.1	70	29.0	0.30	395	28	269	283	0.89	1.2		63
B1F2R9(Laboratory/ Air conditioned)	S1	33.1	28.1	38	28.5	0.57	563	21	362	376	0.98	0.9	100	58
	S2	33.1	26.9	43	28.1	0.46	621	22	320	329	0.97	1.2		59
B1F2R10 (shared office/ Mixed mode conditioned)	S1	33.4	32.1	57	32.9	0.55	353	32	418	432	0.98	1.0	100	63
	S2	33.4	31.7	59	33.0	1.96	354	35	486	511	0.93	0.9		64
	S3	33.4	31.6	59	33.0	0.53	347	33	480	503	0.93	1.2		64
	S4	33.4	31.8	58	32.9	0.80	478	34	489	524	0.92	1.1		66
B1F2R11(shared office/ Air conditioned)	S1	33.1	30.2	49	32.7	0.43	430	25	402	419	0.95	1.0	100	68
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	33.1	32.2	43	33.1	0.82	425	23	142	151	0.99	1.0	0	67
	S2	33.1	31.6	44	32.9	0.65	427	25	143	151	0.93	1.4		67

FIRST FLOOR														
B1F1R1 (Conference room/ Air conditioned)	**S1**	33.1	29.7	39	31.4	0.64	408	17	336	344	0.97	1.0	100	63
	S2	33.1	29.7	39	31.3	0.60	410	17	337	349	0.99	1.0		65
	S3	33.1	29.4	40	31.3	0.70	412	16	373	384	0.97	0.9		69
B1F1R3 (combined two class room/ Air conditioned)	**S1**	33.1	31.9	37	32.2	0.76	407	20	174	180	0.97	1.0	0	67
	S2	33.1	32.2	36	32.0	1.41	401	19	100	103	0.92	1.1		68
	S3	33.1	32.2	36	32.1	0.75	398	20	292	299	0.91	1.1		67
	S4	33.1	30.8	39	32.0	0.49	422	22	172	182	0.90	1.2		51
B1F1R4(shared office/ Air conditioned)	**S1**	33.1	29.4	39	30.7	0.94	538	21	452	477	0.85	1.2	100	51
	S2	33.1	29.0	36	29.9	1.01	545	21	317	328	0.98	1.0		54
B1F1R6 (shared office/ Air conditioned)	**S1**	33.1	27.4	39	27.0	0.62	710	14	531	556	0.94	1.0	100	51
	S2	33.1	28.7	36	27.1	0.36	650	14	345	356	0.94	1.1		50
B1F1R7 (shared office/ Air conditioned)	**S1**	33.1	30.5	52	31.0	0.63	713	21	155	159	0.98	1.0	0	54
	S2	33.1	30.1	41	31.0	0.40	705	20	220	229	0.95	1.1		55
B1F1R8 (individual office/ Air conditioned)	**S1**	33.1	26.7	34	30.8	0.36	476	17	349	356	0.97	1.1	100	57
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	33.1	31.4	45	31.4	0.53	514	24	91	93	0.97	1.1	0	60
	S2	33.1	31.5	45	31.5	1.13	505	25	95	99	0.95	1.1		63
Ground Floor														
B1F0R1 (Classroom / naturally ventilated)	**S1**	32.7	31.1	55	31.5	0.43	863	13	232	242	0.80	1.2	0	69
	S2	32.7	31.1	55	31.5	0.56	867	16	200	209	0.94	1.1		68
	S3	32.7	30.9	61	31.3	0.50	874	14	178	187	0.99	1.2		65
	S4	32.7	31.1	56	31.5	1.73	859	17	185	194	0.98	1.1		73
B1F0R2 (Classroom / naturally ventilated)	**S1**	32.7	31.4	58	31.8	0.50	1064	19	317	331	0.90	1.2	100	65
	S2	32.7	31.2	60	31.6	0.39	1025	21	589	614	0.99	1.0		65
	S3	32.7	31.4	59	31.8	0.44	1051	20	470	491	0.98	1.0		61
	S4	32.7	31.3	59	31.7	0.27	1046	20	586	611	0.98	1.0		61
B1F0R4 (Classroom / naturally ventilated)	**S1**	32.7	31.0	57	31.4	0.25	889	21	311	325	1.00	1.1	50	69
	S2	32.7	31.0	56	31.4	0.37	909	25	297	310	0.95	1.0		76
	S3	32.7	31.1	56	31.5	0.88	880	20	406	423	0.96	1.1		71
	S4	32.7	31.0	56	31.4	0.46	869	19	269	281	0.84	0.9		77

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	76%	83%	83%	72%
Building Class	**-**	**B**	**B**	**-**

c) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken from 21st September, 2017 to 28th September, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality		lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class=15, B class=25, C class=25		at least 250 EMLis present within at leat 75% of work station/not for class C	A class=0.7, B class= 0.7, C class= -	A class=3:1, B class= -, C class= -	A class=90%,B class=80%,C class= 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	33.9	27.8	43	29.1	0.35	555	30	267	283	0.91	1.2	67	64
	S2	33.9	27.9	42	28.8	0.35	564	30	342	365	0.96	0.9		62
	S3	33.9	27.2	43	28.0	0.28	585	30	321	333	0.83	1.1		61
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	33.9	33.1	46	34.1	0.50	458	34	215	223	0.93	1.2	25	67
	S2	33.9	33.5	46	34.2	0.68	480	37	232	239	0.95	1.1		68
	S3	33.9	34.0	46	34.0	0.60	460	35	230	239	0.91	1.1		67
	S4	33.9	32.4	47	33.7	0.66	495	36	260	267	0.95	1.1		67
B2F0R3 (shared office/ Air conditioned)	S1	33.9	29.7	47	30.7	0.15	568	31	276	290	0.92	1.2	33	64
	S2	33.9	30.2	46	30.5	0.79	572	32	381	407	0.96	0.8		65
	S3	33.9	30.5	35	30.5	0.92	579	33	283	290	0.96	1.4		66

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	82%	87%	81%	62%
Building Class	B	B	B	-

5. Results of October, 2017 (Moderate Season)

a) Old Administration Building, MNIT Jaipur

- Measurement taken from 25th October, 2017 to 31st October, 2017

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
BIF2R1 (Laboratory/ Air conditioned)	S1	31.3	30.6	34	30.5	0.67	400	64	140	340	357	0.91	0.9	100	60
	S2	31.3	30.0	33	30.0	0.92	403	60	128	419	432	0.93	0.9		67
	S3	31.3	30.0	34	29.9	1.14	409	62	132	403	425	0.96	1.0		66
	S4	31.3	29.8	33	30.0	0.94	428	63	134	395	407	0.95	1.0		66
B1F2R2(shared office/ Air conditioned)	S1	30.4	28.5	35	28.8	0.37	443	64	131	172	180	1.00	1.0	50	59
	S2	30.4	28.5	36	28.4	0.73	454	53	111	363	387	0.96	0.9		59
B1F2R3(individual office/ Air conditioned)	S1	30.4	27.4	43	29.0	0.62	459	52	99	342	354	0.94	1.0	100	62
	S2	30.4	27.4	43	28.9	0.46	446	47	110	345	358	0.91	1.0		62
B1F2R4(Laboratory/ Air conditioned)	S1	30.6	29.1	38	28.5	0.07	471	68	135	277	291	0.97	1.0	100	58
	S2	30.6	29.0	37	28.4	0.09	503	70	122	593	646	0.92	1.0		52
	S3	30.6	29.1	39	28.4	0.12	523	68	123	682	736	0.96	0.9		53
	S4	30.6	29.0	38	28.4	0.15	502	74	145	312	326	0.96	1.0		51
B1F2R6(shared office/ Air conditioned)	S1	30.6	27.4	35	25.6	0.29	531	63	125	494	544	0.95	1.0	100	58
	S2	30.6	20.9	36	27.1	0.22	529	65	138	322	354	0.97	1.0		60
	S3	30.6	27.6	36	27.3	0.21	536	62	118	553	608	0.98	1.0		60
B1F2R8(Laboratory/ Air conditioned)	S1	30.6	29.7	35	30.0	0.31	477	63	121	411	439	0.97	0.9	100	62
	S2	30.6	28.9	36	30.0	1.19	508	65	129	557	610	0.94	1.0		62
	S3	30.6	29.4	36	28.5	0.26	508	65	125	395	409	0.98	1.0		63
B1F2R9(Laboratory/ Air conditioned)	S1		25.9	39	29.0	0.71	460	57	110	362	386	0.94	1.0	100	63
	S2		25.9	39	28.9	0.55	474	59	112	365	384	0.92	1.0		63
B1F2R10 (shared office/ Mixed mode conditioned)	S1	31.3	30.6	41	31.1	0.52	384	66	143	353	370	0.93	1.0	100	65
	S2	31.3	30.4	43	31.1	1.93	393	64	134	430	452	0.93	1.0		59
	S3	31.3	30.2	44	31.0	0.50	408	65	136	398	421	0.95	1.0		59
	S4	31.3	30.5	42	31.1	0.77	389	63	130	466	499	0.91	0.9		60
B1F2R11(shared office/ Air conditioned)	S1	30.4	28.4	34	28.7	0.56	469	51	104	343	354	0.96	0.9	100	59
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	30.4	28.3	34	28.9	0.84	459	61	120	129	135	0.92	1.0	0	60
	S2	30.4	28.4	35	28.8	0.53	446	56	109	118	124	0.97	1.0		62

FIRST FLOOR															
B1F1R1 (Conference room/ Air conditioned)	**S1**	32.2	29.4	29	30.2	0.74	421	76	154	343	353	0.97	1.0	100	64
	S2	32.2	29.4	26	30.1	0.70	423	60	112	344	357	0.99	1.0		64
	S3	32.2	29.1	30	30.1	0.80	425	63	129	380	392	0.97	1.2		64
B1F1R3 (combined two class room/ Air conditioned)	**S1**	32.2	30.6	27	31.0	0.86	420	60	125	181	188	0.98	1.0	0	66
	S2	32.2	30.9	27	30.8	1.51	414	69	135	107	111	0.93	1.0		65
	S3	32.2	30.9	27	30.9	0.85	411	68	134	299	307	0.92	1.0		67
	S4	32.2	29.5	29	30.8	0.59	435	61	122	179	189	0.90	0.9		66
B1F1R4(shared office/ Air conditioned)	**S1**	32.2	28.1	29	29.5	1.04	551	63	125	459	485	0.86	1.0	100	63
	S2	32.2	27.7	28	28.7	1.11	558	59	120	324	336	0.98	1.0		63
B1F1R6 (shared office/ Air conditioned)	**S1**	32.2	26.1	29	25.8	0.72	723	62	122	538	563	0.94	1.1	100	66
	S2	32.2	27.4	26	25.9	0.46	663	63	117	352	364	0.95	1.0		65
B1F1R7 (shared office/ Air conditioned)	**S1**	32.2	29.2	32	29.8	0.73	726	64	124	162	167	0.98	1.0	0	65
	S2	32.2	28.8	31	29.8	0.50	718	62	122	227	237	0.95	1.0		65
B1F1R8 (individual office/ Air conditioned)	**S1**	32.2	28.4	25	29.6	0.46	489	62	121	356	365	0.97	0.9	100	64
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	32.2	30.1	35	30.2	0.63	527	64	132	98	101	0.97	0.9	0	62
	S2	32.2	30.2	35	30.3	1.23	518	66	136	102	107	0.95	1.0		62
Ground Floor															
B1F0R1 (Classroom / naturally ventilated)	**S1**	31.9	29.9	28	30.3	0.46	897	53	107	235	246	0.80	1.0	0	73
	S2	31.9	30.0	28	30.3	0.59	885	64	116	203	213	0.94	1.0		72
	S3	31.9	29.7	34	30.1	0.53	896	64	132	181	190	0.99	0.9		70
	S4	31.9	30.0	29	30.3	1.76	903	67	123	188	197	0.98	1.0		71
B1F0R2 (Classroom / naturally ventilated)	**S1**	31.9	30.3	31	30.6	0.53	801	69	140	320	334	0.90	0.9	100	70
	S2	31.9	30.1	33	30.4	0.42	829	58	127	592	617	0.99	1.0		66
	S3	31.9	30.3	32	30.6	0.47	804	60	127	473	494	0.98	1.0		68
	S4	31.9	30.2	32	30.5	0.30	810	55	110	589	614	0.98	1.0		67
B1F0R4 (Classroom / naturally ventilated)	**S1**	31.9	29.9	30	30.2	0.28	806	63	114	314	329	1.00	0.9	50	64
	S2	31.9	29.9	29	30.2	0.40	805	64	140	300	313	0.95	1.1		70
	S3	31.9	30.0	29	30.3	0.91	805	62	116	409	427	0.96	1.0		70
	S4	31.9	29.9	29	30.2	0.49	804	57	113	272	284	0.85	1.3		66

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	76%	78%	81%	72%
Building Class	**-**	**B**	**B**	**-**

b) Centre for Energy and Environment Building, MNIT Jaipur

Measurement taken from 26th October, 2017

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	31.8	29.6	31	30.1	1.05	480	66	139	239	253	0.87	1.0	67	67
	S2	31.8	29.9	30	30.3	0.96	512	57	115	400	429	0.93	1.0		65
	S3	31.8	30.1	30	30.4	0.21	536	54	118	339	353	0.85	0.8		68
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	31.8	31.6	22	30.7	0.79	450	62	133	218	226	0.95	1.0	25	68
	S2	31.8	31.2	22	30.4	0.71	441	47	104	272	283	0.95	1.0		69
	S3	31.8	31.1	22	30.4	0.99	438	49	106	277	290	0.94	1.0		70
	S4	31.8	31.0	22	30.5	0.46	451	49	111	258	265	0.91	1.0		68
B2F0R3 (shared office/ Air conditioned)	S1	31.8	31.4	23	30.2	0.33	449	49	108	355	376	0.94	0.9	100	61
	S2	31.8	30.1	23	30.2	0.66	455	48	101	411	441	0.93	1.0		64
	S3	31.8	30.8	22	30.0	1.80	484	52	104	443	466	0.92	1.1		66

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
CEE (B2)	84%	90%	87%	70%
Building Class	**B**	**B**	**B**	**-**

6. Results of November, 2017 (Winter Season)

a) Old Administration Building, MNIT Jaipur

- Measurement taken from 17th November, 2017 to 24th November, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
B1F2R1 (Laboratory/ Mixed mode conditioned)	S1	23.1	23.0	47	22.6	0.20	422	69	105	377	392	0.94	1.0	100	65
	S2	23.1	23.0	47	22.5	0.08	427	66	98	333	352	0.93	1.0		61
	S3	23.1	22.9	47	22.5	0.12	436	67	95	445	466	0.90	0.9		61
	S4	23.1	22.3	48	22.3	0.09	458	67	103	409	425	0.93	1.0		59
B1F2R2(shared office/ Mixed mode conditioned)	S1	23.1	23.3	48	22.6	0.20	452	62	109	343	369	0.96	0.9	100	60
	S2	23.1	23.0	49	22.6	0.16	463	48	128	362	385	0.95	1.0		59
B1F2R3(individual office/ Air conditioned)	S1	23.9	23.3	26	23.2	0.13	468	51	97	307	315	0.93	1.0	100	63
	S2	23.9	23.3	26	23.3	0.16	455	46	107	432	453	0.94	1.0		63
B1F2R4(Laboratory/Mixed mode conditioned)	S1	24.3	24.0	23	24.1	0.20	460	71	134	297	312	0.96	1.0	75	61
	S2	24.3	24.1	23	24.2	0.18	490	72	124	644	702	0.97	0.9		53
	S3	24.3	24.2	24	24.3	0.12	504	70	122	302	318	0.98	1.0		53
	S4	24.3	24.1	23	24.2	0.16	490	77	139	501	533	0.96	1.0		52
B1F2R6(shared office/ Mixed mode conditioned)	S1	24.3	23.6	22	23.7	0.18	508	66	126	513	400	0.98	1.0	100	57
	S2	24.3	23.7	23	23.6	0.16	502	67	131	568	368	0.94	1.0		61
	S3	24.3	23.7	23	23.7	0.22	510	64	117	421	432	0.98	1.0		60
B1F2R8(Laboratory/ Mixed mode conditioned)	S1	24.3	24.4	22	24.3	0.24	481	64	117	491	526	0.95	1.0	100	63
	S2	24.3	23.8	22	23.9	0.25	502	65	121	377	411	0.97	0.9		64
	S3	24.3	24.1	22	24.2	0.19	505	66	119	329	340	0.94	1.0		65
B1F2R9(Laboratory/ Mixed mode conditioned)	S1	23.9	23.3	25	23.2	0.13	469	59	113	357	381	0.92	1.0	100	65
	S2	23.9	23.4	25	23.3	0.12	483	56	101	334	349	0.94	1.0		63
B1F2R10 (shared office/ Mixed mode conditioned)	S1	23.6	23.8	48	23.3	0.17	437	67	107	152	157	1.00	1.0	75	62
	S2	23.6	23.6	48	23.2	0.15	451	65	102	387	407	0.94	0.9		68
	S3	23.6	23.2	49	23.0	0.22	475	65	101	378	389	0.96	1.0		66
	S4	23.6	23.7	48	23.2	0.21	440	63	108	319	327	0.90	0.9		68
B1F2R11(shared office/Mixed mode conditioned)	S1	23.9	23.6	25	23.6	0.11	478	54	103	354	366	0.94	1.0	100	60
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	23.9	23.5	26	23.5	0.15	468	61	119	121	126	0.91	1.0	0	61
	S2	23.9	23.7	26	23.6	0.13	455	53	98	110	116	0.97	1.0		63

FIRST FLOOR															
B1F1R1 (Conference room/ Mixed mode conditioned)	**S1**	25.3	24.6	22	24.5	0.15	589	78	156	349	359	0.97	0.9	100	64
	S2	25.3	24.1	22	24.1	0.16	598	62	114	345	358	0.94	1.0		64
	S3	25.3	24.2	23	24.1	0.21	598	65	132	337	347	0.99	1.0		63
B1F1R3 (combined two class room/ Mixed mode conditioned)	**S1**	25.3	24.6	22	24.6	0.16	462	62	127	100	156	0.92	1.0	0	66
	S2	25.3	24.4	21	24.4	0.13	450	71	137	91	147	0.97	0.9		65
	S3	25.3	24.7	22	24.7	0.15	456	70	137	95	214	0.95	1.0		66
	S4	25.3	24.4	23	24.3	0.10	494	63	124	292	314	0.91	1.0		65
B1F1R4(shared office/ Mixed mode conditioned)	**S1**	25.3	24.5	22	24.5	0.11	540	65	127	172	214	0.90	0.9	0	62
	S2	25.3	24.3	21	24.2	0.10	544	62	122	174	202	0.97	1.0		63
B1F1R6 (shared office/ Mixed mode conditioned)	**S1**	25.3	24.6	21	24.5	0.19	640	64	124	155	159	0.98	1.0	0	66
	S2	25.3	24.4	22	24.3	0.15	580	65	119	220	225	0.95	1.0		65
B1F1R7 (shared office/ Mixed mode conditioned)	**S1**	25.3	24.2	22	24.1	0.12	643	66	126	287	304	0.96	1.0	100	65
	S2	25.3	24.7	23	24.5	0.18	635	65	124	379	405	0.92	1.0		65
B1F1R8 (individual office/ Air conditioned)	**S1**	25.3	24.1	21	24.0	0.16	441	64	123	531	559	0.94	1.1	100	64
B1F1R10 (Waiting Room/ Mixed mode conditioned)	**S1**	25.3	24.0	21	23.9	0.18	552	66	134	336	364	0.97	1.0	100	62
	S2	25.3	24.2	22	24.1	0.14	540	68	139	373	404	0.97	1.2		62
Ground Floor															
B1F0R1 (Classroom / naturally ventilated)	**S1**	25.2	24.0	21	23.9	0.28	1020	54	109	186	193	0.96	1.0	0	77
	S2	25.2	24.2	21	24.1	0.21	1008	65	117	249	264	0.99	1.0		76
	S3	25.2	23.8	21	23.7	0.26	1019	66	133	210	222	0.87	1.0		74
	S4	25.2	24.1	22	24.0	0.27	1026	69	124	199	209	0.88	0.9		75
B1F0R2 (Classroom / naturally ventilated)	**S1**	25.2	24.4	19	24.3	0.14	924	70	141	199	226	0.88	0.9	50	74
	S2	25.2	24.2	21	24.0	0.19	952	59	129	522	541	0.98	1.0		69
	S3	25.2	24.4	20	24.3	0.18	927	62	128	242	269	0.94	0.9		71
	S4	25.2	24.3	20	24.2	0.15	933	57	112	388	398	0.93	1.0		71
B1F0R4 (Classroom / naturally ventilated)	**S1**	25.2	24.1	20	24.1	0.28	929	64	115	345	362	0.95	1.0	100	67
	S2	25.2	24.0	20	23.9	0.26	928	65	141	331	348	0.90	1.2		74
	S3	25.2	24.1	20	23.9	0.22	928	64	117	423	444	0.92	1.1		74
	S4	25.2	24.1	20	23.9	0.21	927	58	115	581	625	0.99	1.0		69

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	78%	59%	73%	83%
Building Class	**-**	**-**	**-**	**B**

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken from 16th November, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Mixed mode conditioned)	S1	25.7	24.9	43	25.1	0.12	473	56	103	266	282	0.94	1.0	67	65
	S2	25.7	24.8	43	25.1	0.15	484	53	95	383	410	0.96	1.0		65
	S3	25.7	24.9	43	25.3	0.11	501	50	98	335	348	0.86	0.9		65
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	25.7	24.6	40	25.4	0.19	448	60	127	276	290	0.95	1.0	0	67
	S2	25.7	25.1	40	25.0	0.20	445	49	107	275	286	0.95	1.0		64
	S3	25.7	24.9	40	25.0	0.23	439	53	109	279	292	0.94	1.0		66
	S4	25.7	24.9	40	25.1	0.24	453	50	107	262	269	0.92	1.0		64
B2F0R3 (shared office/ Mixed mode conditioned)	S1	25.7	24.6	41	24.7	0.23	451	49	105	328	347	0.93	0.9	100	66
	S2	25.7	24.6	41	24.8	0.25	457	49	101	412	441	0.92	1.0		66
	S3	25.7	24.4	41	24.5	0.18	479	52	102	454	477	0.90	1.1		66

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
CEE (B2)	83%	89%	68%	85%
Building Class	**B**	**B**	**-**	**B**

7. Results of December, 2017 (Winter Season)

a) Old Administration Building, MNIT Jaipur

- Measurement taken from 5th December, 2017 to 21st December, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
B1F2R1 (Laboratory/ Mixed mode conditioned)	S1	22.1	22.1	41	21.7	0.14	668	102	166	298	309	0.44	0.7	75	68
	S2	22.1	22.2	41	21.5	0.29	667	104	163	314	332	0.94	0.9		62
	S3	22.1	22.0	41	21.6	0.15	633	107	173	340	350	0.95	0.9		62
	S4	22.1	22.1	41	21.8	0.19	618	110	174	336	346	0.97	0.9		61
B1F2R2(shared office/ Mixed mode conditioned)	S1	21.6	21.1	39	20.5	0.22	459	60	115	334	358	0.99	1.0	100	60
	S2	21.6	20.8	40	20.5	0.18	470	46	134	353	374	0.98	1.0		59
B1F2R3(individual office/ Air conditioned)	S1	21.6	21.1	35	21.1	0.15	475	49	103	298	304	0.96	1.0	50	63
	S2	21.6	21.1	35	21.2	0.18	462	44	113	423	442	0.97	1.0		63
B1F2R4(Laboratory/Mixed mode conditioned)	S1	22.8	21.3	34	21.7	0.12	445	51	78	270	283	0.99	0.9	75	65
	S2	22.8	21.2	33	21.7	0.21	439	50	74	351	380	0.94	1.0		60
	S3	22.8	21.1	33	21.6	0.08	425	48	75	481	511	0.96	1.0		61
	S4	22.8	21.1	33	21.6	0.15	437	49	80	636	685	0.97	0.8		61
B1F2R6(shared office/ Mixed mode conditioned)	S1	20.8	21.3	42	21.4	0.12	575	98	123	168	158	0.98	1.0	67	62
	S2	20.8	21.3	43	21.3	0.14	600	89	149	328	332	0.57	1.4		61
	S3	20.8	21.1	42	21.5	0.07	629	92	128	381	389	0.98	1.0		61
B1F2R8(Laboratory/ Mixed mode conditioned)	S1	20.8	20.8	41	21.3	0.13	532	107	159	152	164	0.87	0.8	33	60
	S2	20.8	21.2	41	21.4	0.06	526	108	160	402	417	0.95	1.0		62
	S3	20.8	21.3	42	21.5	0.08	562	98	144	165	170	0.97	1.0		63
B1F2R9(Laboratory/ Mixed mode conditioned)	S1	21.6	21.1	34	21.1	0.15	476	57	119	348	370	0.95	1.0	100	65
	S2	21.6	21.2	34	21.2	0.14	490	54	107	325	338	0.97	1.0		63
B1F2R10 (shared office/ Mixed mode conditioned)	S1	22.1	22.0	42	21.9	0.19	621	99	150	315	327	1.00	1.0	100	67
	S2	22.1	21.9	42	21.8	0.16	597	97	149	280	298	0.95	1.0		61
	S3	22.1	22.0	42	21.8	0.13	628	90	147	418	435	0.96	0.9		63
	S4	22.1	21.9	43	21.6	0.12	614	97	148	313	324	0.94	0.9		61
B1F2R11(shared office/Mixed mode conditioned)	S1	22.8	21.1	36	21.7	0.08	468	45	70	415	433	0.94	1.0	100	63
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	22.8	21.1	37	21.6	0.05	460	46	79	88	91	0.96	1.0	0	61
	S2	22.8	21.2	37	21.7	0.10	470	46	74	99	103	0.96	1.0		61

FIRST FLOOR															
B1F1R1 (Conference room/ Mixed mode conditioned)	**S1**	23.8	19.9	38	19.7	0.08	635	12	41	348	359	0.96	1.0	100	62
	S2	23.8	20.1	38	19.9	0.14	629	32	96	362	377	0.99	0.6		64
	S3	23.8	20.4	37	20.1	0.14	619	30	44	352	366	0.97	1.0		61
B1F1R3 (combined two class room/ Mixed mode conditioned)	**S1**	23.8	20.9	36	20.7	0.22	461	27	42	127	137	0.94	0.9	0	61
	S2	23.8	21.1	36	20.8	0.21	464	27	44	100	108	0.96	0.9		62
	S3	23.8	21.1	36	20.8	0.17	470	27	42	199	210	0.93	1.0		61
	S4	23.8	20.8	36	20.6	0.16	463	26	40	91	104	0.92	1.0		64
B1F1R4(shared office/ Mixed mode conditioned)	**S1**	23.8	20.6	40	20.5	0.10	457	29	42	835	855	0.87	1.0	100	63
	S2	23.8	20.9	39	20.8	0.12	454	28	43	650	652	0.94	0.9		63
B1F1R6 (shared office/ Mixed mode conditioned)	**S1**	23.8	21.6	39	21.6	0.17	758	26	37	424	456	0.94	1.0	100	65
	S2	23.8	21.1	40	21.1	0.08	645	29	42	995	1079	0.80	1.0		65
B1F1R7 (shared office/ Mixed mode conditioned)	**S1**	23.8	21.2	43	21.0	0.15	522	29	47	216	226	0.97	1.1	50	63
	S2	23.8	21.1	44	20.9	0.14	531	31	46	153	168	0.95	1.0		62
B1F1R8 (individual office/ Air conditioned)	**S1**	23.8	20.8	38	21.0	0.13	502	39	59	354	364	0.96	1.0	100	64
B1F1R10 (Waiting Room/ Mixed mode conditioned)	**S1**	23.8	21.0	37	21.0	0.17	464	29	42	177	188	0.95	1.0	0	64
	S2	23.8	21.0	37	21.0	0.15	462	28	43	177	189	0.98	1.0		65
Ground Floor															
B1F0R1 (Classroom / naturally ventilated)	**S1**	23.3	21.9	40	21.6	0.20	981	34	93	175	180	0.96	1.0	0	74
	S2	23.3	22.0	41	21.8	0.20	969	45	102	238	252	0.99	1.0		73
	S3	23.3	21.7	41	21.4	0.23	980	45	118	199	209	0.86	1.0		72
	S4	23.3	22.0	42	21.7	0.23	987	48	109	188	197	0.88	0.9		72
B1F0R2 (Classroom / naturally ventilated)	**S1**	23.3	22.3	39	22.0	0.19	885	50	126	188	192	0.88	0.9	50	71
	S2	23.3	22.0	41	21.7	0.19	913	39	114	511	528	0.98	1.0		67
	S3	23.3	22.3	40	22.0	0.15	888	41	113	231	238	0.94	0.9		69
	S4	23.3	22.2	40	21.9	0.16	894	36	96	377	386	0.93	1.0		68
B1F0R4 (Classroom / naturally ventilated)	**S1**	23.3	22.0	40	21.8	0.31	890	44	100	334	350	0.95	1.0	100	65
	S2	23.3	21.9	40	21.6	0.27	889	44	126	320	336	0.89	1.0		72
	S3	23.3	21.9	40	21.6	0.22	889	43	101	412	433	0.92	1.2		72
	S4	23.3	21.9	40	21.6	0.23	888	38	99	566	609	0.97	1.0		67

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	79%	77%	70%	76%
Building Class	-	-	-	-

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken from 22nd December, 2017
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Mixed mode conditioned)	S1	24.7	21.9	36	22.0	0.09	476	63	120	226	238	0.93	1.0	67	61
	S2	24.7	22.4	35	22.7	0.06	462	59	111	318	339	0.96	1.0		61
	S3	24.7	22.4	36	22.5	0.07	446	59	108	372	389	0.94	1.0		61
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	24.7	23.3	32	23.1	0.20	456	43	79	220	228	0.97	1.0	75	62
	S2	24.7	23.0	32	22.9	0.17	449	43	86	302	316	0.97	1.0		60
	S3	24.7	23.2	32	23.0	0.29	453	45	99	318	335	0.94	1.0		61
	S4	24.7	22.8	33	22.8	0.11	454	50	91	386	405	0.98	0.7		60
B2F0R3 (shared office/ Mixed mode conditioned)	S1	24.7	22.8	35	22.7	0.04	430	53	95	1131	1233	0.47	3.7	100	61
	S2	24.7	22.6	35	22.4	0.10	433	53	99	387	412	0.97	1.0		62
	S3	24.7	22.6	35	22.5	0.13	431	86	100	307	316	0.95	0.9		61

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
CEE (B2)	84%	77%	71%	96%
Building Class	**B**	**-**	**-**	**A**

8. Results of January, 2018 (Winter Season)

a) Old Administration Building, MNIT Jaipur

- Measurement taken from Measurement taken from 16th January, 2018 to 31st January, 2018

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
B1F2R1 (Laboratory/ Mixed mode conditioned)	S1	22.2	20.9	25	19.3	0.09	556	55	95	421	443	0.96	1.0		69
	S2	22.2	22.3	26	19.1	0.12	547	54	99	417	446	0.95	0.9	100	63
	S3	22.2	22.1	27	19.3	0.07	494	56	102	367	380	0.98	1.0		63
	S4	22.2	20.2	31	19.0	0.09	535	59	107	377	390	0.98	1.0		62
B1F2R2(shared office/ Mixed mode conditioned)	S1	23.1	22.1	43	20.8	0.08	736	42	82	290	307	0.92	0.9	0	61
	S2	23.1	21.7	43	21.2	0.08	579	45	86	152	161	0.94	0.9		60
B1F2R3(individual office/ Air conditioned)	S1	23.1	21.5	44	20.4	0.05	598	42	78	274	284	0.97	1.0	0	64
	S2	23.1	21.7	43	20.3	0.05	596	42	74	222	236	0.94	0.9		64
B1F2R4(Laboratory/Mixed mode conditioned)	S1	23.1	21.1	46	20.8	0.11	399	54	83	302	319	0.97	0.9		66
	S2	23.1	21.3	44	20.0	0.14	454	51	81	448	487	0.91	0.9	100	61
	S3	23.1	21.5	44	20.2	0.11	493	48	81	606	649	0.89	0.9		62
	S4	23.1	21.1	45	20.3	0.10	429	51	80	390	414	0.95	0.9		62
B1F2R6(shared office/ Mixed mode conditioned)	S1	23.8	22.3	40	22.2	0.21	400	88	130	387	417	0.90	0.9		63
	S2	23.8	22.9	39	22.2	0.18	410	84	94	309	330	0.97	1.0	100	62
	S3	23.8	23.3	37	21.9	0.14	415	80	108	796	865	0.82	0.9		62
B1F2R8(Laboratory/ Mixed mode conditioned)	S1	23.8	23.4	37	22.3	0.13	388	81	133	604	661	0.76	0.9		61
	S2	23.8	23.5	37	22.1	0.11	391	80	126	613	654	0.91	0.9	100	63
	S3	23.8	23.6	37	22.1	0.14	403	79	121	328	349	0.95	0.9		64
B1F2R9(Laboratory/ Mixed mode conditioned)	S1	23.8	23.5	38	22.6	0.13	591	43	106	381	399	0.92	1.0	100	66
	S2	23.8	23.6	38	22.5	0.14	603	46	105	352	379	0.99	1.0		64
B1F2R10 (shared office/ Mixed mode conditioned)	S1	21.9	21.2	46	20.4	0.12	452	109	138	458	486	0.98	0.9		68
	S2	21.9	21.0	44	20.4	0.13	443	102	324	432	466	0.70	0.9	100	62
	S3	21.9	21.0	44	20.3	0.12	443	104	138	521	549	0.97	0.9		64
	S4	21.9	21.2	44	20.2	0.12	452	101	131	830	890	0.68	0.9		62
B1F2R11(shared office/Mixed mode conditioned)	S1	21.9	20.7	44	19.7	0.13	457	92	118	402	422	0.95	1.0	100	64
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	21.9	20.5	44	20.0	0.09	459	93	124	90	93	0.97	1.0	0	62
	S2	21.9	20.5	44	19.9	0.09	440	95	129	105	110	0.97	1.0		62

FIRST FLOOR															
B1F1R1 (Conference room/ Mixed mode conditioned)	**S1**	22.9	20.9	37	19.0	0.07	747	46	81	323	331	0.93	1.0	100	60
	S2	22.9	21.0	40	18.9	0.11	762	47	92	354	366	0.98	1.0		62
	S3	22.9	22.0	35	18.9	0.54	735	47	87	356	327	0.96	1.1		59
B1F1R3 (combined two class room/ Mixed mode conditioned)	**S1**	22.9	21.7	34	19.5	0.13	509	48	96	156	165	0.93	0.9	0	59
	S2	22.9	21.6	34	19.3	0.14	482	46	91	103	108	0.94	0.9		60
	S3	22.9	21.7	33	19.1	0.04	513	46	88	214	225	0.87	1.0		59
	S4	22.9	21.7	34	20.2	0.10	533	48	94	106	111	0.95	1.0		62
B1F1R4(shared office/ Mixed mode conditioned)	**S1**	22.9	22.3	37	20.8	0.16	522	44	84	717	690	0.90	1.0	100	61
	S2	22.9	21.9	37	20.6	0.15	508	43	83	615	620	0.85	1.0		61
B1F1R6 (shared office/ Mixed mode conditioned)	**S1**	22.9	21.3	41	21.4	0.08	622	42	83	393	418	0.95	0.9	50	63
	S2	22.9	21.3	39	21.1	0.05	647	43	70	260	276	0.98	0.9		63
B1F1R7 (shared office/ Mixed mode conditioned)	**S1**	22.9	21.8	38	21.2	0.14	549	42	73	159	165	0.90	1.0	0	61
	S2	22.9	22.0	39	20.0	0.12	534	43	76	210	216	0.94	1.0		60
B1F1R8 (individual office/ Air conditioned)	**S1**	22.9	20.9	37	20.5	0.14	559	50	90	419	430	0.95	1.0	100	62
B1F1R10 (Waiting Room/ Mixed mode conditioned)	**S1**	22.9	20.9	39	19.6	0.10	558	46	86	85	87	0.94	1.0	0	62
	S2	22.9	20.9	40	19.6	0.18	561	47	86	80	82	0.97	1.0		63
Ground Floor															
B1F0R1 (Classroom / naturally ventilated)	**S1**	23.5	21.3	37	19.2	0.13	908	65	195	181	186	0.99	1.0	25	75
	S2	23.5	21.9	37	19.3	0.11	921	64	201	171	177	0.71	1.0		74
	S3	23.5	21.5	37	19.0	0.15	946	63	186	282	301	0.99	0.9		73
	S4	23.5	21.7	35	20.3	0.10	801	63	195	154	159	0.94	1.0		73
B1F0R2 (Classroom / naturally ventilated)	**S1**	23.5	21.6	36	19.0	0.09	916	64	194	322	337	0.92	1.0	75	72
	S2	23.5	21.9	36	19.7	0.14	938	64	112	386	408	0.82	0.9		68
	S3	23.5	22.2	35	20.1	0.09	904	64	178	315	332	0.98	1.0		70
	S4	23.5	22.3	34	20.3	0.11	700	64	156	186	194	0.90	1.0		69
B1F0R4 (Classroom / naturally ventilated)	**S1**	23.5	21.9	34	20.4	0.16	933	63	197	334	350	0.95	1.0	100	66
	S2	23.5	21.6	35	19.1	0.21	818	63	188	320	445	0.89	0.7		73
	S3	23.5	21.6	36	19.3	0.11	963	65	197	412	437	0.92	0.9		73
	S4	23.5	21.3	35	19.4	0.11	925	64	203	566	608	0.97	0.9		74

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	80%	83%	81%	77%
Building Class	**B**	**B**	**B**	**-**

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 25th January, 2018
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality			lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/Ambient+500/Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Mixed mode conditioned)	S1	23.1	21.2	44	19.8	0.07	596	133	188	417	448	0.90	0.9		60
	S2	23.1	21.5	41	19.7	0.12	551	120	167	417	448	0.93	0.9	67	60
	S3	23.1	21.6	42	19.6	0.06	607	116	170	333	346	0.84	1.0		60
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	23.1	21.5	37	18.9	0.06	475	79	124	349	371	0.95	0.9		61
	S2	23.1	21.7	40	19.7	0.08	451	99	156	405	429	0.89	0.9		59
	S3	23.1	21.7	39	19.2	0.04	459	90	135	252	263	0.92	1.0	75	60
	S4	23.1	22.4	42	19.5	0.12	446	101	151	247	257	0.93	1.0		59
B2F0R3 (shared office/ Mixed mode conditioned)	S1	23.1	21.6	39	20.0	0.06	431	82	132	604	650	0.82	0.9		60
	S2	23.1	21.7	38	19.4	0.05	428	78	117	302	321	0.96	0.9	100	61
	S3	23.1	21.7	38	19.9	0.05	436	77	122	433	456	0.99	0.9		60

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class= -			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	84%	85%	97%	71%
Building Class	B	B	A	A

9. Results of February, 2018 (Winter Season)

b) Old Administration Building, MNIT Jaipur

- Measurement taken from Measurement taken from 21th February, 2018 to 28th February, 2018

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class=-	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
BIF2R1 (Laboratory/ Air conditioned)	S1	27.5	27.7	35	27.4	0.08	546	50	107	0.29	66	24	145	61	16	504	534	0.96	1.0	100	60
	S2	27.5	27.6	35	27.3	0.26	525	53	114	0.29	66	24	143	59	16	373	397	0.96	1.0		67
	S3	27.5	27.7	35	27.3	0.24	523	50	109	0.30	67	25	141	57	17	288	298	0.97	1.0		66
	S4	27.5	27.5	35	27.3	0.11	524	47	103	0.33	70	28	144	60	17	370	382	0.98	1.0		66
B1F2R2(shared office/ Air	S1	27.5	25.6	34	26.3	0.59	501	22	45	0.31	68	26	170	54	22	425	456	0.87	1.1	50	59
	S2	27.5	25.4	35	26.2	0.58	528	21	40	0.33	70	28	178	55	24	127	137	0.87	0.8		59
B1F2R3(individual office/ Air	S1	27.5	25.5	35	26.2	0.47	547	24	49	0.33	70	28	156	62	15	298	311	0.89	0.9	50	62
	S2	27.5	25.5	35	26.3	0.52	532	24	50	0.36	73	31	161	67	21	321	345	0.90	1.1		62
B1F2R4(Laboratory/ Air conditioned)	S1	27.5	27.7	34	26.6	0.21	626	29	69	0.25	62	20	165	53	18	309	326	0.88	1.0	100	58
	S2	27.5	27.6	34	26.6	0.27	539	29	70	0.25	62	20	158	55	17	564	606	0.95	0.9		52
	S3	27.5	27.1	35	26.7	0.30	551	33	77	0.27	64	22	163	54	16	985	1076	0.86	0.9		53
	S4	27.5	27.7	34	26.8	0.26	546	28	71	0.25	62	20	154	51	18	465	494	0.83	1.1		51
B1F2R6(shared office/ Air conditioned)	S1	28.4	28.2	30	28.1	0.17	566	30	86	0.29	66	24	160	64	14	357	391	0.60	0.8	100	58
	S2	28.4	28.5	29	28.2	0.24	563	27	85	0.33	70	28	154	60	18	313	342	0.91	1.1		60
	S3	28.4	28.5	29	28.3	0.22	552	30	70	0.30	67	25	153	58	14	672	738	0.98	1.0		60
B1F2R8(Laboratory/ Air conditioned)	S1	28.4	27.8	31	27.6	0.22	542	30	81	0.33	70	28	163	67	18	484	529	0.85	1.0	100	62
	S2	28.4	28.0	31	27.6	0.26	545	27	87	0.30	67	25	160	66	16	566	603	0.91	0.9		62
	S3	28.4	28.0	31	27.7	0.20	571	37	66	0.28	65	23	160	63	13	297	314	0.92	1.0		63
B1F2R9(Laboratory/ Air conditioned)	S1	28.4	25.5	35	26.2	0.48	518	26	59	0.33	70	28	156	62	16	328	343	0.95	1.0	100	63
	S2	28.4	26.0	34	26.2	0.33	516	28	59	0.32	69	27	158	64	15	323	338	0.96	1.0		63
B1F2R10 (shared office/ Mixed mode conditioned)	S1	28.4	27.4	32	27.5	0.26	541	26	66	0.34	71	29	158	62	20	442	468	0.96	1.1	100	65
	S2	28.4	27.6	31	27.4	0.16	556	26	63	0.32	69	27	157	67	14	460	496	0.70	0.9		59
	S3	28.4	27.6	32	27.3	0.29	546	26	65	0.33	70	28	156	63	18	431	450	0.96	1.0		59
	S4	28.4	27.6	32	27.4	0.37	534	29	72	0.33	70	28	160	65	19	455	478	0.97	0.9		60
B1F2R11(shared office/ Air conditioned)	S1	28.4	27.4	32	27.2	0.50	557	25	63	0.31	68	26	154	59	10	348	362	0.95	1.0	100	59
B1F2R12 (Waiting lobby/ naturally	S1	28.4	27.3	31	27.0	0.41	524	25	63	0.29	66	24	152	55	13	88	91	0.95	1.0	0	60
	S2	28.4	27.3	31	27.1	0.37	532	26	63	0.30	67	25	152	56	13	81	83	0.95	0.9		62

FIRST FLOOR																					
B1F1R1 (Conference room/ Air conditioned)	**S1**	28.5	27.2	40	26.7	0.27	553	37	120	0.46	83	41	159	60	33	358	369	0.99	0.9	100	64
	S2	28.5	27.1	40	26.8	0.23	575	33	116	0.35	72	30	151	52	22	390	404	0.89	1.1		64
	S3	28.5	27.2	40	26.7	0.44	547	37	121	0.35	72	30	166	67	22	391	407	0.96	1.0		64
B1F1R3 (combined two class room/ Air conditioned)	**S1**	28.5	28.4	36	27.9	0.20	548	36	87	0.33	70	28	170	72	20	220	235	0.87	1.0	0	66
	S2	28.5	28.1	36	27.8	0.11	593	36	85	0.28	65	23	175	69	15	134	142	0.94	1.0		65
	S3	28.5	28.0	36	27.7	0.14	547	35	84	0.30	67	25	176	68	17	297	316	0.90	1.0		67
	S4	28.5	28.4	36	28.3	0.17	586	32	88	0.34	71	29	177	73	21	251	270	0.94	1.0		66
B1F1R4(shared office/ Air	**S1**	28.5	28.7	36	28.0	0.23	549	34	78	0.27	64	22	172	70	14	287	323	0.93	0.9	100	63
	S2	28.5	28.7	36	28.2	0.20	568	33	79	0.26	63	21	171	71	13	354	303	0.95	1.1		63
B1F1R6 (shared office/ Air	**S1**	28.5	28.2	36	27.7	0.04	528	32	78	0.30	67	25	161	74	17	308	324	0.98	0.9	100	66
	S2	28.5	28.2	37	27.6	0.10	550	32	87	0.43	80	38	169	67	30	324	347	0.96	1.1		65
B1F1R7 (shared office/ Air	**S1**	28.5	27.6	41	27.8	0.14	546	34	85	0.28	65	23	167	61	10	186	195	0.80	1.1	0	65
	S2	28.5	27.9	40	27.7	0.10	548	35	74	0.31	68	26	160	59	8	221	228	0.99	0.9		65
B1F1R8 (individual office/ Air conditioned)	**S1**	28.5	27.7	38	27.1	0.18	569	33	90	0.34	71	29	167	62	19	347	364	0.96	1.0	100	64
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	28.5	27.9	40	27.6	0.31	558	31	113	0.33	70	28	164	58	20	106	111	0.92	0.9	0	62
	S2	28.5	27.8	40	27.8	0.40	576	34	81	0.30	67	25	162	66	17	114	120	0.92	1.1		62
Ground Floor																					
B1F0R1 (Classroom / naturally ventilated)	**S1**	28	27.0	37	27.5	0.31	903	46	156	0.33	70	28	170	65	20	161	169	0.98	0.9	0	73
	S2	28	27.6	37	27.6	0.36	916	46	162	0.31	68	26	166	69	18	151	155	0.67	1.0		72
	S3	28	27.2	37	27.3	0.17	941	45	147	0.37	74	32	164	63	19	262	279	0.99	1.0		70
	S4	28	27.4	35	28.2	0.27	796	45	156	0.29	66	24	164	67	13	134	137	0.93	0.8		71
B1F0R2 (Classroom / naturally ventilated)	**S1**	28	27.3	36	27.3	0.33	911	46	156	0.28	65	23	163	61	12	302	315	0.92	0.9	100	70
	S2	28	27.6	35	27.8	0.68	933	46	73	0.34	71	29	157	55	21	366	386	0.81	1.1		66
	S3	28	27.9	35	27.5	0.25	899	45	139	0.38	75	33	159	59	20	295	310	0.98	1.0		68
	S4	28	28.0	33	27.7	0.15	745	46	118	0.31	68	26	166	64	16	166	172	0.88	1.2		67
B1F0R4 (Classroom / naturally ventilated)	**S1**	28	27.6	34	28.3	0.36	928	45	158	0.30	67	25	168	71	17	314	328	0.95	1.0	100	73
	S2	28	27.3	35	27.4	0.30	813	45	149	0.35	72	30	172	68	22	300	317	0.88	1.0		70
	S3	28	27.3	35	27.6	0.41	958	46	158	0.30	67	25	174	72	17	392	415	0.91	1.0		70
	S4	28	27.0	34	27.7	1.39	920	46	164	0.30	67	25	171	71	17	546	586	0.97	1.0		66

Occupant satisfaction survey results				
	Threshold Value: A class=90% ,B class=80% ,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	78%	80%	84%	77%
Building Class	-	B	B	-

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 20th February, 2018
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class=-	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surrounding	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	28.5	28.8	36	27.4	0.60	491	28	82	0.28	65	23	160	65	12	218	229	0.82	1.0	67	68
	S2	28.5	28.8	36	28.1	0.55	499	28	84	0.32	69	27	166	63	19	355	379	0.96	1.0		64
	S3	28.5	28.9	35	28.1	0.32	487	29	94	0.34	71	29	163	64	21	352	367	0.89	1.0		70
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	28.5	29.2	34	28.0	0.37	489	28	85	0.26	63	21	159	67	11	234	245	0.93	1.0	25	69
	S2	28.5	28.9	34	27.4	0.20	482	28	96	0.31	68	26	157	57	18	303	317	0.93	1.0		71
	S3	28.5	29.2	34	28.1	0.48	493	28	73	0.26	63	21	160	62	11	342	361	0.94	1.0		69
	S4	28.5	28.9	34	27.6	0.31	483	29	104	0.35	72	30	156	62	18	330	348	0.96	1.0		66
B2F0R3 (shared office/ Air conditioned)	S1	28.5	29.1	35	27.8	0.10	496	37	166	0.29	66	24	158	65	16	407	433	0.89	1.2	100	60
	S2	28.5	29.2	36	27.8	0.52	499	39	169	0.31	68	26	166	64	16	391	419	0.97	1.3		62
	S3	28.5	29.3	36	27.9	0.70	510	39	172	0.32	69	27	172	67	18	293	303	0.83	0.7		67

Occupant satisfaction survey results				
Building	Threshold Value: A class=90%,B class=80%,C class=-			
	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	85%	92%	84%	76%
Building Class	B	B	B	-

10. Results of March, 2018 (Moderate Season)

(a) Old Administration Building, MNIT Jaipur

- Measurement taken from Measurement taken from 9th March, 2018 to 16th March, 2018

		Thermal Comfort					Indoor air quality							lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<30, B class<100, C class= -	A class<40, B class<80, C class< -	A class<40, B class<80, C class= -	A class<50, B class<100, C class= -		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
BIF2R1 (Laboratory/ Air conditioned)	S1	31.3	30.6	34	30.5	0.67	400	64	140	757	1315	393	269	340	357	0.91	0.9	100	60
	S2	31.3	30.0	33	30.0	0.92	403	60	128	773	1302	407	275	419	432	0.93	0.9		67
	S3	31.3	30.0	34	29.9	1.14	409	62	132	797	1294	406	247	403	425	0.96	1.0		66
	S4	31.3	29.8	33	30.0	0.94	428	63	134	786	1291	390	253	395	407	0.95	1.0		66
B1F2R2(shared office/ Air conditioned)	S1	30.4	28.5	35	28.8	0.37	443	64	131	1013	1359	354	243	172	180	1.00	1.0	50	59
	S2	30.4	28.5	36	28.4	0.73	454	53	111	939	1557	388	231	363	387	0.96	0.9		59
B1F2R3(individual office/ Air conditioned)	S1	30.4	27.4	43	29.0	0.62	459	52	99	916	903	341	217	342	354	0.94	1.0	100	62
	S2	30.4	27.4	43	28.9	0.46	446	47	110	933	1269	314	210	345	358	0.91	1.0		62
B1F2R4(Laboratory/ Air conditioned)	S1	30.6	29.1	38	28.5	0.07	471	68	135	1046	1283	396	235	277	291	0.97	1.0	100	58
	S2	30.6	29.0	37	28.4	0.09	503	70	122	986	1530	391	235	593	646	0.92	1.0		52
	S3	30.6	29.1	39	28.4	0.12	523	68	123	1026	1556	435	226	682	736	0.96	0.9		53
	S4	30.6	29.0	38	28.4	0.15	502	74	145	1040	1542	404	232	312	326	0.96	1.0		51
B1F2R6(shared office/ Air conditioned)	S1	30.6	27.4	35	25.6	0.29	531	63	125	887	1561	442	222	494	544	0.95	1.0	100	58
	S2	30.6	20.9	36	27.1	0.22	529	65	138	879	1605	456	226	322	354	0.97	1.0		60
	S3	30.6	27.6	36	27.3	0.21	536	62	118	925	1592	454	237	553	608	0.98	1.0		60
B1F2R8(Laboratory/ Air conditioned)	S1	30.6	29.7	35	30.0	0.31	477	63	121	821	1595	463	248	411	439	0.97	0.9	100	62
	S2	30.6	28.9	36	30.0	1.19	508	65	129	896	1592	492	249	557	610	0.94	1.0		62
	S3	30.6	29.4	36	28.5	0.26	508	65	125	868	1609	466	243	395	409	0.98	1.0		63
B1F2R9(Laboratory/ Air conditioned)	S1		25.9	39	29.0	0.71	460	57	110	890	1147	375	229	362	386	0.94	1.0	100	63
	S2		25.9	39	28.9	0.55	474	59	112	896	1153	381	235	365	384	0.92	1.0		63
B1F2R10 (shared office/ Mixed mode conditioned)	S1	31.3	30.6	41	31.1	0.52	384	66	143	759	1317	395	271	353	370	0.93	1.0	100	65
	S2	31.3	30.4	43	31.1	1.93	393	64	134	799	1296	408	249	430	452	0.93	1.0		59
	S3	31.3	30.2	44	31.0	0.50	408	65	136	788	1293	392	255	398	421	0.95	1.0		59
	S4	31.3	30.5	42	31.1	0.77	389	63	130	775	1304	409	277	466	499	0.91	0.9		60
B1F2R11(shared office/ Air conditioned)	S1	30.4	28.4	34	28.7	0.56	469	51	104	933	1560	408	229	343	354	0.96	0.9	100	59
B1F2R12 (Waiting lobby/ naturally ventilated)	S1	30.4	28.3	34	28.9	0.84	459	61	120	941	1561	388	236	129	135	0.92	1.0	0	60
	S2	30.4	28.4	35	28.8	0.53	446	56	109	883	1140	368	222	118	124	0.97	1.0		62

FIRST FLOOR																			
B1F1R1 (Conference room/ Air conditioned)	**S1**	32.2	29.4	29	30.2	0.74	421	76	154	685	1262	442	263	343	353	0.97	1.0	100	64
	S2	32.2	29.4	26	30.1	0.70	423	60	112	693	1252	439	267	344	357	0.99	1.0		64
	S3	32.2	29.1	30	30.1	0.80	425	63	129	666	1267	408	269	380	392	0.97	1.2		64
B1F1R3 (combined two class room/ Air conditioned)	**S1**	32.2	30.6	27	31.0	0.86	420	60	125	564	1268	433	264	181	188	0.98	1.0	0	66
	S2	32.2	30.9	27	30.8	1.51	414	69	135	777	1236	424	262	107	111	0.93	1.0		65
	S3	32.2	30.9	27	30.9	0.85	411	68	134	766	1237	408	266	299	307	0.92	1.0		67
	S4	32.2	29.5	29	30.8	0.59	435	61	122	494	1161	436	249	179	189	0.90	0.9		66
B1F1R4(shared office/ Air conditioned)	**S1**	32.2	28.1	29	29.5	1.04	551	63	125	559	1167	409	244	459	485	0.86	1.0	100	63
	S2	32.2	27.7	28	28.7	1.11	558	59	120	610	1192	434	258	324	336	0.98	1.0		63
B1F1R6 (shared office/ Air conditioned)	**S1**	32.2	26.1	29	25.8	0.72	723	62	122	653	1239	458	251	538	563	0.94	1.1	100	66
	S2	32.2	27.4	26	25.9	0.46	663	63	117	729	1236	431	245	352	364	0.95	1.0		65
B1F1R7 (shared office/ Air conditioned)	**S1**	32.2	29.2	32	29.8	0.73	726	64	124	597	1270	432	263	162	167	0.98	1.0	0	65
	S2	32.2	28.8	31	29.8	0.50	718	62	122	592	1302	436	260	227	237	0.95	1.0		65
B1F1R8 (individual office/ Air conditioned)	**S1**	32.2	28.4	25	29.6	0.46	489	62	121	692	1242	432	254	356	365	0.97	0.9	100	64
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	32.2	30.1	35	30.2	0.63	527	64	132	709	1268	422	265	98	101	0.97	0.9	0	62
	S2	32.2	30.2	35	30.3	1.23	518	66	136	670	1260	442	277	102	107	0.95	1.0		62
Ground Floor																			
B1F0R1 (Classroom / naturally ventilated)	**S1**	31.9	29.9	28	30.3	0.46	897	53	107	958	1567	401	218	235	246	0.80	1.0	0	73
	S2	31.9	30.0	28	30.3	0.59	885	64	116	954	1582	405	232	203	213	0.94	1.0		72
	S3	31.9	29.7	34	30.1	0.53	896	64	132	942	1571	417	250	181	190	0.99	0.9		70
	S4	31.9	30.0	29	30.3	1.76	903	67	123	968	1569	385	221	188	197	0.98	1.0		71
B1F0R2 (Classroom / naturally ventilated)	**S1**	31.9	30.3	31	30.6	0.53	801	69	140	1024	1372	371	248	320	334	0.90	0.9	100	70
	S2	31.9	30.1	33	30.4	0.42	829	58	127	893	1590	463	220	592	617	0.99	1.0		66
	S3	31.9	30.3	32	30.6	0.47	804	60	127	856	1578	457	236	473	494	0.98	1.0		68
	S4	31.9	30.2	32	30.5	0.30	810	55	110	898	1579	462	215	589	614	0.98	1.0		67
B1F0R4 (Classroom / naturally ventilated)	**S1**	31.9	29.9	30	30.2	0.28	806	63	114	976	1520	422	220	314	329	1.00	0.9	50	64
	S2	31.9	29.9	29	30.2	0.40	805	64	140	929	1533	406	223	300	313	0.95	1.1		70
	S3	31.9	30.0	29	30.3	0.91	805	62	116	897	1547	407	219	409	427	0.96	1.0		70
	S4	31.9	29.9	29	30.2	0.49	804	57	113	882	1563	435	226	272	284	0.85	1.3		66

Occupant satisfaction survey results				
	Threshold Value: A class=90% ,B class=80% ,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	76%	78%	81%	72%
Building Class	-	**B**	**B**	-

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 8th March, 2018

		Thermal Comfort					Indoor air quality							lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EML is present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	31.8	29.6	31	30.1	1.05	480	66	139	765	911	347	230	239	253	0.87	1.0	67	67
	S2	31.8	29.9	30	30.3	0.96	512	57	115	745	1044	404	251	400	429	0.93	1.0		65
	S3	31.8	30.1	30	30.4	0.21	536	54	118	714	1045	407	229	339	353	0.85	0.8		68
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	31.8	31.6	22	30.7	0.79	450	62	133	473	1254	432	253	218	226	0.95	1.0	25	68
	S2	31.8	31.2	22	30.4	0.71	441	47	104	541	1219	425	245	272	283	0.95	1.0		69
	S3	31.8	31.1	22	30.4	0.99	438	49	106	385	1202	430	254	277	290	0.94	1.0		70
	S4	31.8	31.0	22	30.5	0.46	451	49	111	428	1213	444	248	258	265	0.91	1.0		68
B2F0R3 (shared office/ Air conditioned)	S1	31.8	31.4	23	30.2	0.33	449	49	108	592	1139	455	250	355	376	0.94	0.9	100	61
	S2	31.8	30.1	23	30.2	0.66	455	48	101	556	1194	431	238	411	441	0.93	1.0		64
	S3	31.8	30.8	22	30.0	1.80	484	52	104	571	1148	435	241	443	466	0.92	1.1		66

Occupant satisfaction survey results				
Building	Threshold Value: A class=90%,B class=80%,C class=-			
	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	84%	90%	87%	70%
Building Class	B	B	B	-

11. Results of April, 2018 (Summer Season)

(a) Old Administration Building, MNIT Jaipur

- Measurement taken from Measurement taken from 23th April, 2018 to 30th April, 2018

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class=-	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
B1F2R1 (Laboratory/ Air conditioned)	S1	39.5	29.0	38	31.3	0.24	455	21	60	0.71	44	18	187	33	21	246	254	0.91	1.0	75	63
	S2	39.5	29.4	40	30.0	1.69	471	21	63	0.66	42	18	201	35	22	187	195	0.95	1.0		70
	S3	39.5	29.2	39	30.7	0.48	457	22	61	0.66	49	18	184	31	24	254	263	0.97	1.1		69
	S4	39.5	29.7	35	30.2	1.22	451	22	71	0.68	51	20	196	29	21	330	349	0.97	1.0		69
B1F2R2(shared office/ Air	S1	39.9	26.3	43	28.5	0.31	624	27	52	0.72	72	22	172	32	17	346	374	0.59	1.7	50	62
	S2	39.9	25.5	44	29.5	0.96	626	27	54	0.66	56	23	193	34	26	202	210	0.96	0.8		62
B1F2R3(individual office/ Air	S1	39.9	26.0	39	29.0	0.51	603	30	50	0.66	74	21	208	35	21	233	241	0.98	1.0	50	65
	S2	39.9	26.0	39	28.8	0.57	589	32	49	0.66	58	18	221	37	23	246	254	0.88	1.1		65
B1F2R4(Laboratory/ Air conditioned)	S1	39.1	27.7	28	30.0	0.11	602	20	54	0.67	53	25	204	32	18	394	420	0.97	0.9	100	61
	S2	39.1	29.8	28	30.0	0.10	520	22	55	0.69	56	17	201	26	17	618	673	0.92	1.0		55
	S3	39.1	30.0	29	30.9	0.15	532	19	61	1	58	22	196	37	25	770	830	0.94	0.8		56
	S4	39.1	29.5	28	30.3	0.10	512	19	63	1	53	19	214	36	26	489	524	0.98	0.8		54
B1F2R6(shared office/ Air conditioned)	S1	39.1	29.2	34	29.5	0.51	536	25	67	0.72	68	20	218	37	27	140	148	0.86	0.8	33	61
	S2	39.1	29.3	33	30.1	1.17	551	25	69	0.74	61	17	190	37	25	131	138	0.94	1.0		63
	S3	39.1	29.5	31	30.1	0.53	572	26	66	0.69	50	15	174	31	24	248	268	0.90	1.0		63
B1F2R8(Laboratory/ Air conditioned)	S1	39.1	30.8	36	32.6	0.17	406	31	133	0.74	59	17	174	26	19	244	265	0.82	1.2	67	65
	S2	39.1	31.6	30	30.9	0.43	505	31	100	0.69	57	21	201	31	19	428	451	0.93	1.1		65
	S3	39.1	30.7	31	30.9	0.60	506	31	95	0.75	62	19	211	32	17	169	176	0.90	1.0		66
B1F2R9(Laboratory/ Air conditioned)	S1	39.9	25.0	43	26.0	1.10	907	45	115	0.68	56	21	196	35	21	339	353	0.97	1.2	50	66
	S2	39.9	25.2	43	25.8	0.48	913	42	109	0.67	60	16	190	36	22	303	317	0.98	0.9		66
B1F2R10 (shared office/ Mixed mode conditioned)	S1	39.5	30.5	28	33.2	0.40	514	21	71	0.67	47	23	228	40	32	377	397	0.99	1.4	75	68
	S2	39.5	32.9	22	34.3	1.86	504	20	62	0.69	56	20	213	34	37	262	278	0.87	1.1		62
	S3	39.5	31.9	25	34.1	0.38	518	20	59	0.67	49	25	217	40	29	369	385	0.95	1.1		62
	S4	39.5	33.5	29	34.2	1.42	513	20	60	0.67	50	24	200	32	23	227	239	0.91	1.1		63
B1F2R11(shared office/ Air conditioned)	S1	39.9	31.3	25	32.0	1.05	447	30	91	0.64	55	17	203	34	27	332	345	0.98	0.9	100	62
B1F2R12 (Waiting lobby/ naturally	S1	39.9	29.6	26	32.3	0.56	487	34	107	0.66	57	23	214	36	21	74	77	0.89	1.0	0	63
	S2	39.9	31.4	28	32.4	0.49	500	33	94	0.65	63	19	194	29	24	78	82	0.94	1.0		65

FIRST FLOOR																				
B1F1R1 (Conference room/ Air conditioned)	**S1**	35.2	30.4	21	31.5	0.55	536	20	44	0.68	71	37	243	53	30	308	325	0.58	0.9	67	62
	S2	35.2	29.4	22	30.6	0.66	554	20	46	0.71	72	35	235	54	29	275	286	0.95	0.9		62
	S3	35.2	32.9	24	32.7	0.71	580	21	49	0.70	75	41	262	62	46	220	230	0.96	1.0		62
B1F1R3 (combined two class room/ Air conditioned)	**S1**	35.2	32.5	18	33.9	0.61	518	28	81	0.74	72	27	165	38	22	255	274	0.96	1.0	50	64
	S2	35.2	32.4	18	33.7	0.49	499	27	74	0.72	63	29	183	41	20	207	223	0.92	1.1		63
	S3	35.2	32.6	18	33.9	0.57	506	26	72	0.78	67	29	190	44	22	441	475	0.88	1.2		65
	S4	35.2	32.1	17	33.5	0.69	501	27	79	0.70	69	30	188	38	25	210	225	0.86	1.1		64
B1F1R4(shared office/ Air	**S1**	35.2	29.1	32	30.3	0.53	663	23	48	0.69	71	34	227	54	39	477	504	0.93	1.0	100	61
	S2	35.2	28.9	32	30.1	0.47	652	24	50	0.70	71	38	223	51	36	467	492	0.95	1.0		61
B1F1R6 (shared office/ Air	**S1**	35.2	29.5	29	30.6	0.32	683	16	36	0.73	74	45	243	58	36	391	414	0.96	1.1	50	64
	S2	35.2	29.0	31	30.1	0.39	693	18	40	0.72	75	35	222	45	29	286	305	0.93	0.9		63
B1F1R7 (shared office/ Air	**S1**	35.2	30.3	28	31.3	0.37	572	20	42	0.79	85	38	207	49	31	170	177	0.82	1.0	0	63
	S2	35.2	30.0	28	30.9	0.18	585	20	46	0.74	85	35	223	51	29	257	273	0.94	1.1		63
B1F1R8 (individual office/ Air conditioned)	**S1**	35.2	28.1	36	29.3	1.02	559	25	52	0.69	71	37	209	39	26	489	505	0.93	1.0	100	62
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	35.2	30.3	24	31.8	0.15	564	23	56	0.71	73	40	229	50	28	81	84	0.96	0.9	0	60
	S2	35.2	31.1	24	32.4	0.14	563	23	56	0.77	77	37	216	51	26	86	89	0.95	1.0		60
Ground Floor																				
B1F0R1 (Classroom / naturally ventilated)	**S1**	41.1	36.6	26	36.3	0.59	867	60	189	0.61	63	35	255	45	21	181	186	0.99	0.9	25	78
	S2	41.1	36.5	25	36.2	0.64	880	59	195	0.55	57	29	253	44	19	171	177	0.71	1.0		77
	S3	41.1	37.0	26	36.7	0.45	905	59	180	0.57	67	26	235	42	14	282	301	0.99	1.0		75
	S4	41.1	35.1	24	34.8	0.55	760	59	189	0.53	61	31	245	42	14	154	159	0.94	0.8		76
B1F0R2 (Classroom / naturally ventilated)	**S1**	41.1	35.9	25	35.6	0.61	875	59	189	0.56	77	23	223	40	14	322	337	0.92	0.9	100	75
	S2	41.1	35.4	24	35.1	0.96	897	59	176	0.61	75	22	196	34	13	386	408	0.82	1.1		71
	S3	41.1	35.4	24	35.1	0.96	897	59	176	0.61	75	22	196	34	13	386	408	0.82	1.1		73
	S4	41.1	34.6	24	34.3	0.53	863	59	172	0.56	71	22	203	37	15	315	332	0.98	1.0		72
B1F0R4 (Classroom / naturally ventilated)	**S1**	41.1	35.7	24	35.4	0.62	879	59	190	0.51	66	33	242	45	20	284	298	0.97	0.9	75	69
	S2	41.1	34.7	24	34.4	0.58	777	59	182	0.57	69	25	246	46	30	320	335	0.89	1.0		75
	S3	41.1	35.2	24	34.9	0.69	922	60	191	0.64	62	32	229	33	21	412	437	0.92	1.0		75
	S4	41.1	34.4	23	34.1	1.67	884	59	198	0.60	60	22	211	28	19	566	608	0.97	1.0		71

Occupant satisfaction survey results				
	Threshold Value: A class=90% ,B class=80% ,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	78%	82%	85%	77%
Building Class	-	**B**	**B**	-

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 20th May, 2018

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class=-	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surrounding	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	35.9	31.5	27	31.7	0.53	695	30	70	0.70	78	35	215	41	36	261	276	0.87	0.9	0	64
	S2	35.9	31.7	27	31.0	0.62	700	30	68	0.66	79	32	210	42	37	252	266	0.91	1.7		62
	S3	35.9	30.2	29	30.2	1.00	699	30	76	0.61	83	33	180	39	34	253	266	0.77	0.9		65
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	35.9	32.5	37	32.6	0.74	508	34	92	0.63	91	34	243	40	38	210	218	0.96	1.0	0	65
	S2	35.9	30.6	39	31.8	0.33	477	34	87	0.66	82	34	227	45	38	230	237	0.96	0.9		66
	S3	35.9	31.6	38	31.9	0.98	496	34	88	0.66	89	38	225	46	39	230	238	0.98	1.0		67
	S4	35.9	29.6	41	31.3	1.44	321	34	90	0.70	83	35	221	42	34	258	269	0.85	1.0		65
B2F0R3 (shared office/ Air conditioned)	S1	35.9	30.9	31	31.1	0.20	591	38	93	0.61	82	34	228	41	33	194	201	0.75	1.6	0	58
	S2	35.9	31.0	31	31.2	0.60	598	36	108	0.67	82	36	244	41	35	283	300	0.98	1.5		61
	S3	35.9	30.4	31	31.0	1.74	610	36	109	0.68	89	31	234	44	34	197	206	0.92	0.7		63

Occupant satisfaction survey results				
	Threshold Value: A class=90%,B class=80%,C class=-			
Building	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort
CEE (B2)	82%	84%	85%	74%
Building Class	B	B	B	-

12. Results of May, 2018 (Summer Season)

(b) Old Administration Building, MNIT Jaipur

- Measurement taken from Measurement taken from 16th May, 2018 to 24th May, 2018

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class= -	A class<30, B class<100, C class= -	A class<40, B class<80, C class<-	A class<40, B class<80, C class= -	A class<50, B class<100, C class= -		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
Room Code (Utility/ type)	Seating Code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound (dB)
B1F2R1 (Laboratory/ Air conditioned)	S1	38.3	31.8	48	34.7	0.22	463	50	127	0.67	63	47	268	50	25	342	357	0.91	1.0	75	64
	S2	38.3	31.7	48	33.6	2.10	456	42	129	0.70	70	33	250	51	28	230	242	0.97	0.9		71
	S3	38.3	31.2	49	32.9	0.73	460	55	137	0.66	68	30	227	47	24	260	270	0.99	1.0		70
	S4	38.3	30.8	51	32.6	0.69	465	51	131	0.67	64	31	256	49	27	322	340	0.95	1.0		70
B1F2R2(shared office/ Air	S1	40.1	28.1	42	30.4	0.93	609	23	51	0.67	51	19	222	32	20	198	206	0.94	0.9	0	63
	S2	40.1	28.4	42	30.6	0.57	605	24	48	0.70	51	20	204	26	15	143	152	0.94	1.3		63
B1F2R3(individual office/ Air	S1	40.1	29.6	36	30.9	0.47	730	31	67	0.62	51	22	236	39	25	245	252	0.98	1.0	0	66
	S2	40.1	28.7	36	29.8	0.29	753	29	54	0.64	48	24	226	38	17	257	274	0.89	1.1		66
B1F2R4(Laboratory/ Air conditioned)	S1	40.1	30.6	28	32.1	0.25	585	28	65	0.67	59	15	193	32	16	298	314	0.92	0.9	100	62
	S2	40.1	30.1	30	31.8	0.16	603	26	57	0.64	49	21	199	31	12	514	559	0.92	1.0		56
	S3	40.1	29.1	29	33.2	0.12	548	28	59	0.60	48	24	233	36	19	519	553	0.90	0.8		57
	S4	40.1	29.3	29	31.3	0.33	543	27	54	0.62	49	19	216	33	13	473	506	0.98	0.8		55
B1F2R6(shared office/ Air conditioned)	S1	38.9	29.9	41	31.0	0.92	709	35	67	0.57	55	23	247	32	23	151	160	0.89	0.9	0	62
	S2	38.9	30.0	41	31.4	0.88	716	34	64	0.57	59	18	246	36	20	169	179	0.96	0.5		64
	S3	38.9	30.7	40	31.5	0.31	735	32	64	0.56	57	28	259	40	24	268	289	0.76	1.0		64
B1F2R8(Laboratory/ Air conditioned)	S1	38.9	30.5	44	31.6	0.19	525	61	132	0.55	55	22	248	34	23	261	284	0.86	1.1	33	66
	S2	38.9	30.7	45	31.4	1.14	510	60	135	0.57	56	16	228	36	18	429	452	0.87	1.0		66
	S3	38.9	31.0	40	32.2	0.34	501	60	127	0.56	56	30	243	38	18	169	175	0.94	1.0		67
B1F2R9(Laboratory/ Air conditioned)	S1	40.1	26.5	42	28.9	0.41	648	25	48	0.70	51	14	185	24	17	322	333	0.95	1.0	100	67
	S2	40.1	27.4	43	30.4	0.44	674	25	48	0.69	56	13	182	27	17	323	338	0.94	1.0		67
B1F2R10 (shared office/ Mixed mode conditioned)	S1	38.3	33.1	41	35.1	0.36	460	55	124	0.72	68	36	255	43	23	355	372	0.99	1.5	50	69
	S2	38.3	34.0	39	35.2	1.40	454	49	133	0.71	62	30	233	50	24	258	274	0.95	1.0		63
	S3	38.3	34.3	39	35.4	0.63	461	51	130	0.79	62	30	245	47	26	331	344	0.98	1.1		63
	S4	38.3	34.7	37	35.4	1.62	471	49	124	0.71	63	31	233	46	21	195	204	0.91	1.0		64
B1F2R11(shared office/ Air conditioned)	S1	38.9	33.7	25	34.8	0.73	470	47	125	0.56	52	31	266	39	22	318	330	0.89	1.0	100	63
B1F2R12 (Waiting lobby/ naturally	S1	38.9	34.3	25	34.7	0.57	473	48	126	0.57	57	23	239	39	21	91	95	0.90	1.1	0	64
	S2	38.9	34.2	25	35.2	0.30	502	48	136	0.59	54	23	233	38	29	79	83	0.86	1.1		66

FIRST FLOOR																					
B1F1R1 (Conference room/ Air conditioned)	**S1**	40.8	34.1	18	35	0.68	546	18	40	0.68	42	34	250	46	22	295	311	0.55	0.9	67	61
	S2	40.8	35.6	20	35	0.79	564	18	42	0.73	49	29	234	39	22	262	272	0.95	0.9		61
	S3	40.8	34.3	21	34.2	0.84	590	19	45	0.67	45	34	240	43	22	207	217	0.96	1.0		61
B1F1R3 (combined two class room/ Air conditioned)	**S1**	40.8	37.6	15	37.4	0.74	528	26	77	0.70	48	30	240	49	26	242	260	0.95	1.0	50	63
	S2	40.8	37.3	15	37.4	0.62	509	25	71	0.71	55	31	249	47	32	190	204	0.93	1.1		62
	S3	40.8	37.5	15	37.5	0.70	516	25	68	0.77	51	31	213	44	25	428	461	0.87	1.2		64
	S4	40.8	37.4	14	37.4	0.82	514	26	75	0.69	57	31	249	46	29	197	211	0.86	1.1		63
B1F1R4(shared office/ Air	**S1**	40.8	30.1	29	33.0	0.66	673	21	45	0.67	53	34	262	55	37	464	489	0.93	1.0	100	60
	S2	40.8	30.2	29	33.3	0.60	662	22	46	0.69	51	48	273	53	28	454	477	0.95	1.0		60
B1F1R6 (shared office/ Air	**S1**	40.8	31.9	26	33.1	0.45	693	14	32	0.66	46	30	228	44	20	378	400	0.96	1.1	100	63
	S2	40.8	31.4	28	33.0	0.52	703	16	36	0.65	46	31	219	43	25	273	290	0.92	0.9		62
B1F1R7 (shared office/ Air	**S1**	40.8	31.1	25	31.9	0.50	582	18	38	0.69	42	34	264	51	32	157	163	0.80	1.0	0	62
	S2	40.8	30.9	25	32.2	0.31	595	18	43	0.67	49	35	268	54	29	244	259	0.93	1.1		62
B1F1R8 (individual office/ Air conditioned)	**S1**	40.8	29.3	33	31.5	1.15	569	23	48	0.69	52	38	262	42	27	476	491	0.93	1.0	100	61
B1F1R10 (Waiting Room/ Air conditioned)	**S1**	40.8	34.1	21	35.1	0.23	574	21	52	0.69	48	31	254	47	24	68	69	0.96	0.9	0	59
	S2	40.8	34.5	11	33.4	0.22	573	21	53	0.74	45	31	248	39	23	73	75	0.95	1.0		59
Ground Floor																					
B1F0R1 (Classroom / naturally ventilated)	**S1**	42.7	37.7	21	37	0.66	840	38	134	0.70	63	35	268	45	21	175	182	0.98	0.9	25	70
	S2	42.7	37.6	21	37.3	0.71	853	39	141	0.64	57	29	266	44	19	165	172	0.70	1.0		69
	S3	42.7	38.1	22	37.8	0.52	878	38	134	0.66	67	26	248	42	14	276	294	0.99	1.0		67
	S4	42.7	36.2	20	35.9	0.62	733	38	138	0.62	61	31	258	42	14	148	153	0.94	0.8		68
B1F0R2 (Classroom / naturally ventilated)	**S1**	42.7	37.0	20	36.7	0.68	848	38	132	0.65	77	23	236	40	14	316	330	0.92	0.9	100	67
	S2	42.7	36.5	20	36.2	1.03	870	38	123	0.70	75	22	209	34	13	380	401	0.81	1.1		63
	S3	42.7	36.5	20	36.2	1.03	870	38	123	0.70	75	22	209	34	13	380	401	0.81	1.1		65
	S4	42.7	35.7	19	35.4	0.60	836	38	111	0.65	71	22	216	37	15	309	325	0.98	1.0		64
B1F0R4 (Classroom / naturally ventilated)	**S1**	42.7	36.0	18	35.7	0.71	865	38	142	0.60	65	28	257	46	25	328	343	0.95	1.0	100	61
	S2	42.7	35.8	19	35.5	0.65	750	38	136	0.66	69	25	259	46	30	314	329	0.89	1.0		67
	S3	42.7	36.3	20	36.0	0.76	895	38	136	0.73	62	32	242	33	21	406	431	0.91	1.0		67
	S4	42.7	35.5	19	35.2	1.74	857	39	144	0.69	60	22	224	28	19	560	601	0.97	1.0		63

Occupant satisfaction survey results				
	Threshold Value: A class=90% ,B class=80% ,C class= -			
Building	**Thermal Comfort**	**Indoor Air quality**	**Lighting comfort**	**Acoustic Comfort**
Old Admin Block (B1)	77%	86%	81%	80%
Building Class	-	B	B	B

b) Centre for Energy and Environment Building, MNIT Jaipur

- Measurement taken on 25th May, 2018
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

		Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class=-	A class<30, B class<100, C class=-	A class<40, B class<80, C class<-	A class<40, B class<80, C class=-	A class<50, B class<100, C class=-		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class=-	A class<3:1, B class=-, C class=-	A class>90%,B class>80%,C class> 80%	
Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surrounding	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
B2F0R1 (shared office/ Air conditioned)	S1	40.9	34.1	25	34.3	0.62	712	29	67	0.75	71	31	218	37	28	268	284	0.87	0.9	0	65
	S2	40.9	33.9	25	33.6	0.71	717	28	65	0.71	72	28	213	38	29	254	268	0.92	1.7		63
	S3	40.9	32.8	27	32.8	1.09	716	28	73	0.66	76	29	183	35	26	260	274	0.78	0.9		66
B2F0R2 (Laboratory, shared office / Mixed mode conditioned)	S1	40.9	35.1	27	32.8	1.09	716	28	73	0.66	76	29	183	35	26	260	274	0.78	0.9	0	66
	S2	40.9	33.2	37	34.4	0.42	494	33	85	0.71	75	30	230	41	30	237	245	0.96	0.9		67
	S3	40.9	34.2	36	34.5	1.07	513	32	85	0.71	82	34	228	42	31	237	246	0.98	1.0		68
	S4	40.9	32.2	39	33.9	1.53	338	32	87	0.75	76	31	224	38	26	265	277	0.85	1.0		66
B2F0R3 (shared office/ Air conditioned)	S1	40.9	33.5	29	33.7	0.29	608	37	91	0.66	75	30	231	37	25	201	209	0.76	1.6	0	59
	S2	40.9	33.6	29	33.8	0.69	615	34	106	0.72	75	32	247	37	27	290	308	0.98	1.5		62
	S3	40.9	33.0	29	33.6	1.83	627	34	106	0.73	82	27	237	40	26	204	213	0.92	0.7		64
Occupant satisfaction survey results																					
Building	Threshold Value: A class=90%,B class=80%,C class=-																				
	Thermal Comfort	Indoor Air quality	Lighting comfort	Acoustic Comfort																	
CEE (B2)	78%	90%	87%	70%																	
Building Class	B	B	B	-																	

c) Residential Building, MNIT Jaipur

- Measurement taken on 28th May to 1st June, 2018
- Time slot for measurement are morning session (10.00am to 11.00am), afternoon session (2.00pm to 3.00pm) and evening session (4.00pm to 5.00pm)

			Thermal Comfort					Indoor air quality									lighting comfort					Acoustic Comfort
	Color Code: A Class: Green B Class: Purple C Class: Red Out of any class: Red	threshold value	Not specified	24.5+-2.5°C	30-70%	A class 17-31°C only	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A class<15, B class<25, C class<25	A class<50, B class<100, C class<100	A class<2, B class<9, C class<-	A class<100, B class<500, C class= -	A class<30, B class<100, C class= -	A class<40, B class<80, C class< -	A class<40, B class<80, C class= -	A class<50, B class<100, C class= -		at least 250 EMLis present within at leat 75% of work station/not for class C	A class>0.7, B class> 0.7, C class= -	A class<3:1, B class= -, C class= -	A class>90%,B class>80%,C class> 80%	
	Room Code (Utility / Type)	Seating code	Ambient Temperature(°C)	Operative temperature(°C)	RH(%)	Floor surface temperature(°C)	Air velocity(m/s)	CO2(ppm)	PM2.5(ug/m3)	PM10(ug/m3)	CO (ppm)	TVOC(ug/m3)	CH2O(ug/m3)	SO2(ug/m3)	NO2(ug/m3)	O3(ug/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance within task area	Ratio of illuminance task area to immediate surroundings	Percentage of the task area meeting the required illuminance	Overall Sound pressure Level (dB)
28-May	B3F0R1 (Bed Room/ naturally ventilated)	S1	42.8	37.1	17	36.8	0.81	469	37	91	1.20	125	48	98	33	28	168	184	0.89	0.9	0	61
	B3F0R2 (Bed Room/ naturally ventilated)	S1	42.8	37.1	20	36.8	1.09	458	34	95	1.11	130	46	63	31	26	160	174	0.81	0.9	0	61
		S2	42.8	37.2	20	36.9	0.78	466	29	85	1.16	129	47	110	37	30	138	145	0.94	0.9		63
	B3F0R3 (living room/ Air conditioned)	S1	42.8	35.5	25	35.2	1.21	449	39	91	1.17	132	47	111	33	25	105	113	0.94	1.6	0	65
		S2	42.8	35.6	25	35.3	0.89	456	34	106	1.24	129	49	127	33	27	121	149	0.98	1.5		60
	B3F0R4 (Kitchan/ naturally ventilated)	S1	42.8	37.5	21	37.2	0.15	651	108	239	6.42	354	129	315	98	25	101	109	0.71		0	84
29-May	B3F0R1 (Bed Room/ naturally ventilated)	S1	42.6	36.7	20	36.5	0.88	476	39	99	1.40	117	45	90	30	26	171	189	0.90	1.1	0	64
	B3F0R2 (Bed Room/ naturally ventilated)	S1	42.6	36.7	24	36.5	1.16	465	36	103	1.31	122	43	55	28	24	163	179	0.82	1.1	0	64
		S2	42.6	36.8	23	36.6	0.85	473	31	93	1.36	121	44	102	34	28	141	150	0.95	1.1		66
	B3F0R3 (living room/ Air conditioned)	S1	42.6	35.1	30	34.9	1.28	456	41	99	1.37	124	44	103	30	27	108	118	0.95	1.8	0	68
		S2	42.6	35.2	31	35.0	0.96	463	36	114	1.44	121	46	119	30	29	124	154	0.99	1.7		63
	B3F0R4 (Kitchan/ naturally ventilated)	S1	42.6	37.1	23	36.9	0.22	658	112	247	5.69	346	126	307	93	27	104	114	0.72	0.2	0	87
30-May	B3F0R1 (Bed Room/ naturally ventilated)	S1	36.9	31.6	33	31.4	0.83	482	28	83	0.99	134	51	85	27	25	163	177	0.78	0.9	0	66
	B3F0R2 (Bed Room/ naturally ventilated)	S1	36.9	31.6	37	31.4	1.11	471	25	87	0.90	139	49	50	25	23	155	167	0.78	0.9	0	66
		S2	36.9	31.7	36	31.5	0.80	479	20	77	0.95	138	50	97	31	27	133	138	0.96	0.9		68
	B3F0R3 (living room/ Air conditioned)	S1	36.9	30.0	43	29.8	1.23	462	30	83	0.96	141	50	98	27	22	100	106	0.98	1.0	0	70
		S2	36.9	30.1	44	29.9	0.91	469	25	98	1.03	138	52	114	27	24	116	142	0.85	1.0		65
	B3F0R4 (Kitchan/ naturally ventilated)	S1	36.9	32.0	36	31.8	0.17	664	101	231	6.21	363	132	302	90	22	96	102	0.76	1.6	0	89
31-May	B3F0R1 (Bed Room/ naturally ventilated)	S1	38.5	32.4	31	32.2	0.87	489	30	88	1.51	139	49	87	29	28	173	192	0.98	1.5	0	63
	B3F0R2 (Bed Room/ naturally ventilated)	S1	38.5	32.4	35	32.2	1.15	478	27	92	1.42	144	47	52	27	26	165	182	0.92	0.7	0	63
		S2	38.5	32.5	34	32.3	0.84	486	22	82	1.47	143	48	99	33	30	143	153	0.94	0.8		65
	B3F0R3 (living room/ Air conditioned)	S1	38.5	30.8	41	30.6	1.27	469	32	88	1.48	146	48	100	29	29	110	121	0.92	0.9	0	67
		S2	38.5	30.9	42	30.7	0.95	476	27	103	1.55	143	50	116	29	31	126	157	0.81	1.1		62
	B3F0R4 (Kitchan/ naturally ventilated)	S1	38.5	32.8	34	32.6	0.21	671	103	236	5.80	368	130	304	92	29	106	117	0.81	1.1	0	86
1-Jun	B3F0R1 (Bed Room/ naturally ventilated)	S1	39.1	33.5	28	33.3	0.80	475	32	92	1.06	142	50	86	31	27	167	184	0.98	1.0	0	64
	B3F0R2 (Bed Room/ naturally ventilated)	S1	39.1	33.5	32	33.3	1.08	464	29	96	0.97	147	48	51	29	25	159	174	0.96	1.1	0	64
		S2	39.1	33.6	31	33.4	0.77	472	24	86	1.02	146	49	98	35	29	137	145	0.92	0.9		66
	B3F0R3 (living room/ Air conditioned)	S1	39.1	31.9	38	31.7	1.20	455	34	92	1.03	149	49	99	31	24	104	113	0.80	1.0	0	68
		S2	39.1	32.0	39	31.8	0.88	462	29	107	1.10	146	51	115	31	26	120	149	0.93	1.1		63
	B3F0R4 (Kitchan/ naturally ventilated)	S1	39.1	33.9	31	33.7	0.14	657	105	240	6.28	371	131	303	94	24	100	109	0.93	1.0	0	87

Results of summer monitoring in Chennai (March to June)

		Thermal Comfort					Indoor Air quality										Lighting Comfort					Acoustic Comfort
Colour Code Class A – GREEN Class B – Purple Class C - Red		Not Specified	30-70%	A Class 17-31°C only	24.5±2.5°C	Not Specified	Ambient+350/ Ambient+500/ Ambient+700	A Class<15, B Class<25, C Class<25	A Class<50, B Class<100, C Class<100	A Class<2, B Class<9,	A Class<200, B Class<500, C Class<500	A Class<50, B Class<100, C Class -	A Class<40, B Class<80, C Class -	A Class<40, B Class<80, C Class -	A Class<30, B Class<100, C Class -			At least 250 EML is present within at least 75% of work station/not for	A Class =0.7, B Class= 0.7, C Class= -	A Class =3:1, B Class= - , C Class= -	A Class = 90%, B Class = 80%, C Class = -	
Place	Location	Ta (°C)	RH (%)	Surface Temperature (°C)	To (°C)	Va (m/s)	CO_2 (ppm)	PM2.5 (µg/m³)	PM10 (µg/m³)	CO (ppm)	TVOC (µg/m³)	O_3 (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)	CH_2O (µg/m³)	Total Microbial Count (CFU/m³)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance	Ratio of Illuminance of task area to immediate surrounding Area	% of task area meeting the required Illuminance	Overall Sound Pressure level (dB)
R1	Hall	32.1	44.4	31	32.3	1.73	470	20.4	47.4	0.43	8.66	20.8	40.2	32	0	360	45.3	34.428	1.00	0.76	0	62.5
	Kitchen	32.2	49.4	31.5	32.25	0.12	502	21.3	50.6	0.65	145.77	19.5	45.6	37	0	190	23	17.48	0.96	0.72	0	65.6
	Bed Room	32	48.4	31.4	32.1	0.66	510	20.1	46.6	0	6.33	18.9	44.3	35	11	810	45	34.2	0.98	0.80	0	60.53
R2	Hall	33	44.5	34.2	33.2	0.15	508.5	30.8	49	0.05	7.56	17.5	75.6	35	0	420	118	89.68	0.99	0.89	0	70.71
	Kitchen	33.2	45.6	33.5	33.25	0.18	512.6	30.9	49.5	0.66	160.13	18.25	70.6	40	0	210	78	59.28	0.99	0.95	0	64.4
	Bed Room	32	46.8	32.5	32.5	0.10	520.8	22.1	44.0	0	8.63	17.25	79.66	43	14	820	120	91.2	0.98	1.00	100	64.3
O1	S1	25.3	42.8	25.48	24.35	0.06	970	11.39	24.62	0	5.338	20.5	43	25	28	1440	167.3	127.148	1.00	0.98	0	65.79
	S2	25.9	50.9	28.8	25.15	0.19	870	10.2	22.5	0	3.32	19.5	41	20	12	1480	145	110.2	0.99	0.93	0	66.8
	S3	24.7	46.5	27.4	24.55	0.28	865	10	21.1	0	4.38	21.9	39	23	24	1380	120	91.2	0.99	0.96	0	74.2
O2	S1	27.3	45.2	30	27.35	0.29	946	3.7	5.8	0	2	20.1	68	29	70	760	302.6	229.976	1.00	0.86	100	70.2
	S2	27.9	47.2	28	27.75	0.03	1178	4.2	9.7	0	2	20.3	65	38	46	840	954.3	725.268	1.00	0.99	100	62.5
	S3	27.9	44.2	22.6	28.05	0.06	1004	3.8	7.7	0	8	19.9	69	29	70	980	29.3	22.268	1.00	0.98	0	69.5
	S4	27.3	41.5	27.9	27.2	0.02	1077	4.9	10.7	0	6	19.1	66	35	16	890	193.6	147.136	1.00	0.98	0	65.4
R3	Hall	33.65	45.87	33.5	33.29	0.06	392.7	15.04	30.75	0.04	22.2	18.5	74	38	7	780	48	36.48	0.98	0.96	0	66.75
	Room A	33.8	46.75	33.5	33.38	0.06	412	24.35	41.85	0	10.342	18.5	78.6	39	10	650	31.75	24.13	0.91	0.91	0	66.75
	Room B	33.5	48.25	33.5	33.52	0.06	842	23.19	58.66	0	3.819	20.3	78	40	11	220	49.5	37.62	0.98	0.95	0	66.75
	Study	33.6	49.32	33.5	33.88	0.06	530	22.39	56.25	0	2.233	19.25	78	35	16	560	46	34.96	0.98	0.96	0	66.75
	Kitchen	36	43.2	33.5	35.9	0.07	540	25.63	59.32	0.62	29.68	19.39	73	44	8	510	61.25	46.55	0.98	0.97	0	68.2
I1	S1	26.5	47.1	27.2	25.9	0.21	1117	3.03	9.6	0	2.3	24.6	45	24	51.6	650	156.5	118.94	0.99	0.99	0	67.1
	S2	24.5	47.6	27.05	24.5	0.085	1057	2.6	7.75	0	2.6	26.3	44	23	62.5	690	123.3	93.708	0.99	0.99	0	70.7
	S3	26.55	50.55	28.25	26.4	0.2	1127	2.4	6.35	0	7.33	26.3	49	22	64	580	239	181.64	1.00	0.94	0	71.75
I3	S1	32.75	49.8	30.5	32.9	1	647	18.9	39.5	0	2.7	24.1	40	43	51.5	480	72.83	55.3508	0.99	0.93	0	71.45

	S2	31.05	48.65	29.25	31.55	0.375	743	14	27.5	0	2.3	25.3	42	34	51.5	470	144	109.44	0.99	0.99	0	71.05
C2	P1	32.2	49	27.2	31.6	0.26	570	112.6	144.2	0	7	23.2	45	26	3	480	73.6	55.936	0.99	0.98	0	60
	P2	32.1	45	27.4	31.5	0.21	550	115.3	150.3	0	7.3	25.2	48	30	2	520	75.5	57.38	0.99	0.97	0	65.3
C1	S1	28.4	47.3	28.4	28.3	0.1	1180	3.25	8.35	0	3	20.6	25	20	7	1680	199.3	151.468	0.99	0.97	0	66.5
	S2	29	50	28.5	28.9	0.03	1134	2.9	6.8	0	3	21.6	35	23	2	1650	160	121.6	0.99	0.97	0	63.5
	S3	29.6	45.6	28.5	29.3	0.95	1456	2.6	6	0	2	22.5	32	24	4	1720	162.3	123.348	0.99	0.97	0	63.5
O3	S1	25.7	48.4	32.2	24.8	0.28	1083	6.03	13.08	0	5.85	20.95	27.8	22.2	17	1600	153	116.28	0.99	0.97	0	76.2
O4	S1	27.4	47.11	27.5	25.7	0.07	1099	11.8	24.45	0	5.14	19.28	36	22.6	11	1890	155	117.8	0.97	0.94	0	81.7

Occupant Satisfactory Results (Summer)				
Threshold Value : A Class= 90%, B Class= 80%, C Class= -				
Building	Thermal Comfort	Indoor Air Quality	Lighting Comfort	Acoustic Comfort
I1	75%	68%	80%	83%
I3	80%	85%	95%	93%
O1	83%	70%	65%	95%
O2	70%	85%	90%	85%
O3	93%	87%	85%	83%
O4	90%	90%	95%	85%
C1	93%	85%	90%	80%
C2	85%	90%	95%	90%
R1	80%	90%	70%	80%
R2	78%	85%	90%	70%
R3	83%	80%	75%	80%

Results of monsoon monitoring in Chennai (July-November)

Thermal Comfort						Indoor Air quality										Lighting Comfort					Acoustic Comfort
Colour Code Class A – GREEN Class B – Purple Class C - Red	Not Specified	30-70%	A Class 17-31°C only	24.5±2.5°C	Not Specified	Ambient+350/ Ambient+500/ Ambient+700	A Class<15, B Class<25, C Class<25	A Class<50, B Class<100, C Class<100	A Class<2, B Class<9, C Class<9	A Class<200, B Class<500, C Class<500	A Class<50, B Class<100, C Class -	A Class<40, B Class<80, C Class -	A Class<40, B Class<80, C Class -	A Class<30, B Class<100, C Class -			At least 250 EML is present within at least 75% of work station/not for class C	A Class =0.7, B Class=0.7, C Class=-	A Class =3:1, B Class=-, C Class=-	A Class = 90%, B Class = 80%, C Class = -	
Place	Ta (°C)	RH (%)	Surface Temperature (°C)	To (°C)	Va (m/s)	CO_2 (ppm)	PM2.5 (µg/m³)	PM10 (µg/m³)	CO (ppm)	TVOC (µg/m³)	O_3 (µg/m³)	SO_2 (µg/m³)	NO_2 (µg/m³)	CH_2O (µg/m³)	Total Microbial Count (CFU/m³)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance	Illuminance of task area to immediate surrounding	% of task area meeting the required illuminance	Overall Sound Pressure level (dB)
R1	31.36	68.96	29.78	32.22	1.04	426.17	19.86	41.63	0.23	53.58	14.4	31.7	31	49.14	543	50	38	0.94	0.87	0	108.08
R2	31.93	65.95	29.68	32.75	0.22	356.66	20.9	43.63	0.268	8.77	13.14	64.8	35.67	44	586	89	67	0.97	0.88	0	105.12
O1	25.23	69.05	27.2	25.18	0.15	681.5	8.3	18.05	0	3.138	14.59	31.33	16.33	47.71	1636	108	82	0.94	0.89	0	84.62
O2	27.56	62.24	28.65	27.32	0.14	1318	5.75	11.23	0	4.34	15.96	56.5	27.25	56.83	982	60	137	0.96	0.90	0	63.28
O3	28.45	69.6	27.5	28.72	0.07	1016	14.98	25.36	0	4.5	16.85	17.6	17.4	56.5	1836	175	133	0.98	0.93	0	105.8
O4	28.43	63.56	27.35	27.44	0.07	1080	14.38	27.13	0	2.66	15.66	26.5	18.4	60.33	2063	174	132	0.98	0.94	0	99.08
C1	28.49	63.3	28.56	28.48	0.08	1067.6	4.13	10.7	0	4.07	15	31.67	17.67	61.71	1840	140	106	0.97	0.91	0	62.6
C2	28.07	64.44	29.53	27.67	0.17	886.17	8.5	19.78	0	2.5	14.15	38.5	23	63.14	605	126	95	0.97	0.92	0	60.5
I1	27.48	66.61	28.78	27.18	0.31	763.5	4.47	9.3	0	7.15	20.96	36.67	18.67	51.42	743	192	146	0.97	0.99	0	102.65
I3	30.9	63.58	29.4	30.4	0.64	1010	18.87	46.16	0.055	2.8	20.66	33	35.5	26	530	87	66	0.97	0.93	0	67.38

Occupant Satisfactory Results (Monsoon)				
Threshold Value : A Class= 90%, B Class= 80%, C Class= -				
Building	Thermal Comfort	Indoor Air Quality	Lighting Comfort	Acoustic Comfort
I1	90%	90%	95%	85%
I3	93%	85%	90%	80%
O1	85%	90%	95%	90%
O2	80%	90%	70%	80%
O3	78%	85%	90%	70%
O4	83%	80%	75%	80%
C1	83%	70%	65%	95%
C2	70%	85%	90%	85%
R1	93%	87%	85%	83%

Results of winter monitoring in Chennai (December-February)

	Thermal Comfort					Indoor Air quality							Lighting Comfort					Acoustic Comfort
Colour code Class A – GREEN Class B – Purple Class C - Red	Not Specified	30-70%	A Class 17-31oC only	22.0±3°C	Not specified	Ambient+350/ Ambient+500/ Ambient+700	A Class<15, B Class<25, C Class<25	A Class<50, B Class<100, C Class<100	A Class<2, B & C Class<9,	A Class<200, B Class<500, C Class<500	A Class<50, B Class<100, C Class -			At least 250 EML is present within at least 75% of work station/not for class C	A Class =0.7, B Class= 0.7, C Class= -	A Class =3:1, B Class= - , C Class= -	A Class = 90%, B Class = 80%, C Class = -	
Place	Ta (°C)	RH (%)	Surface Temperature (°C)	To (°C)	Va (m/s)	CO2 (ppm)	PM2.5 (µg/m3)	PM10 (µg/m3)	CO (ppm)	TVOC (µg/m3)	O3 (µg/m3)	Total Microbial Count (CFU/m3)	Illuminance (Lux)	Circadian Lighting Design (EML)	Uniformity of Illuminance	Ratio of Illuminance of task area to immediate surrounding Area	% of task area meeting the required illuminance	Overall Sound Pressure level (dB)
C1	23.12	53.3	23.48	23.58	0.03	1160.46	14.85	16.79	0	9	17.08	2023	165	125	0.97	0.91	0	66.51
I1	25.26	55.93	25.66	25.33	0.13	390.6	52.71	65.49	0	20	13.67	870	156	119	0.98	0.93	0	69.42
I2	25.26	55.6	25.7	25.03	0.09	326.59	45.18	58.65	0	21.8	13.72	665	157	120	0.98	0.95	0	72.23
O3	23.83	59.16	23.68	23.09	0.01	1012.87	7.57	13.52	0	9.85	16.8	2037	206	157	0.97	0.86	0	71.97
O4	23.76	59.2	23.54	23.86	0.01	669.52	8.19	12.96	0	9.42	16.63	2363	196	149	0.97	0.88	0	69.82
O1	23.22	52.17	23.51	23.18	0.008	521.79	14.21	24.09	0	7.5	15.5	1850	167	128	0.97	0.91	0	67.67

Occupant Satisfactory Results (Winter)				
Threshold Value : A Class= 90%, B Class= 80%, C Class= -				
Building	Thermal Comfort	Indoor Air Quality	Lighting Comfort	Acoustic Comfort
I1	90%	90%	95%	85%
I2	93%	85%	90%	80%
O1	85%	90%	95%	90%
O3	80%	90%	70%	80%
O4	78%	85%	90%	70%
C1	83%	80%	75%	80%