Analyzing Sick Building Syndrome in Architecture Studios of EMU

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ABSTRACT

Sick building syndrome (SBS) is one of the important issues of our contemporary age where people are facing problems derived from buildings, and this issue is becoming an important concern especially in modern life due to its heavy consequences. SBS includes various general symptoms that affect the users of a building. The SBS effect can be seen on individuals as a group of symptoms which appear specifically at working places. Some of the common symptoms are headache; loss of concentration, runny nose, itching, dry skin and dry eyes. The most important characteristic of SBS is such that it is not always easy to recognize the problem and the lack of awareness amongst designers and users about SBS causes other problems like reducing of the productivity of the employees in a working place or learning capacity of students in an educational building. Recognizing and finding proper solutions for problems in sick buildings will help create healthy environments and lead to more productiveness at work, therefore it is important to be aware of the subject and take it serious specially at this modern era where these issues matters a lot. In this research, signs of SBS will be observed and analyzed in the Architectural Studios of EMU (A18, A27) as the case study of research because it is very important for an educational building to provide a healthy environment that students can perform better and have the maximum productivity. The methodology of research is a mix of qualitative and quantitative approach to collect required data. The aim is to find out if the users of studios are suffering from sick building syndrome effects and propose some possible solutions for their improvement. For this purpose, the named lecture/studio rooms of interior architecture have been analyzed with observations and questionnaires where possible factors leading to SBS has been pinned.. After collection of sufficient data and their

analysis, the results showed that the building is suffering from SBS impacts; students were effected by some of SBS syndromes and it affected their performance and health conditions.

Keywords: Educational Building, SBS, Health, User, EMU

ÖZ

Hasta bina sendromu, insanların bundan kaynaklanan problemlerle karşı karşıya kaldığı çok önemli bir konudur ve bu konu, özellikle modern yaşamda, sonuçlarının ağır olabileceği önemli bir sorun haline gelmektedir. Hasta bina sendromu, bir binadaki kullanıcılarda meydana gelen farklı genel belirtileri içerir. SBS etkisi, bireylerde özellikle çalışma yerlerinde görülen bir semptom grubu olarak tanımlanabilir. Sık görülen semptomlardan bazıları baş ağrısı; konsantrasyon kaybı, burun akıntısı, kaşıntı, kuru cilt ve gözlerde kuruluktur. Bu konuda yaşanan en önemli sıkıntılarından bazıları, çalışanların işyerindeki üretkenliklerinin azalması ve öğrencilerin eğitim binalarındaki öğrenme kapasitelerinin azalması gibi sorunların ortaya çıkmasıdır. Ancak kullanıcıların bu problemi tanıyabilecek kadar yeterli farkındalıklarının olması her zaman karşılaşılan bir durum değildir. Hasta binalardakı problemlere uygun çözümleri tanımak ve bulmak, kullanıcılara sağlıklı bir ortam oluşturacak ve kullanıcıların üretkenliğini artıracağı için, bu konuları farkında olmak ve özel önem vermek önemlidir. Bu araştırmada, SBS belirtileri, bir eğitim binası öğrencilerine sağlıklı bir ortam sağlamak için çok önemli olduğundan, DAÜ Mimarlık Stüdyoları (A18, A27) araştırmanın örnek çalışması olarak gözlemlenecek ve analiz edilecektir. Araştırma metodolojisi, gerekli verilerin toplanmasında niteliksel ve niceliksel yaklaşımlardan yararlanmıştır. Amaç, stüdyo kullanıcılarının hasta bina sendromu etkilerinden olumsuz etkilenip etkilenmediklerini anlamak üzere binaları analiz etmek olası faktörleri göz önünde bulundurarak bazı çözümler önermek ve aynı zamanda anketler aracılığı ile bina içinde iken kullanıcıların durumunu gözlemlemektir. Yeterli veri topladıktan ve analiz ettikten sonra sonuçlar seçilen mekanlarda hasta bina sendromu etkisinin olduğunu göstermiştir. Öğrenciler SBS

sendromunun bazılarından etkilenmiş ve bu durum performanslarını ve sağlık durumlarını da etkilemiştir.

Anahtar Kelimeler: Eğitim Binası, HBS, Sağlık, Kullanıcı, DAÜ

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INTRODUCTION

Buildings should provide a healthy, safe and comfortable environment for their occupants which means a condition that users can perform at their best according to function of building without any disturbance or disorder caused by building condition. Sick Building Syndrome, SBS has been certified as a recognizable disease by the World Health Organization (Lindvall, T. 1986). Since 1986, attentions have been drawn to subject and it has been a main concern to identify a cause and eliminate it from occupied buildings or those at the design stage. Estimations demonstrate that up to 30% of renovated buildings and an obscure however huge number of new buildings probably are suffering from SBS. The impact of SBS on people is a number of symptoms which have been seen and reported mostly at working environments like offices or educational buildings. The most common symptoms are itching, loss or lack of concentration, runny nose, headache, dry skin, lethargy, dryness or irritation of throat and dry eye (Sykes, J.M. 1988).

The ‘American Standards for Heating, Refrigeration and Air-Conditioning Engineers’ claims that a building could be called ‘sick’ if twenty percent or more of the users or occupants complain of suffering from discomfort symptoms for periods more than two weeks and also the affected users realize fast relief from the symptoms when they leave the building’ (Passarelli, G. R. 2009).`

There are many different factors that causes the creation of SBS signs like ventilation problems, lighting, air pollutants, psychological factors and etc. Some of these factors which are most likely to be found in the selected building according to conditions like building dimensions, indoor air quality, visual comfort, acoustic comfort and psychological conditions are analyzed and taken into account at this research.

Anybody might be influenced by SBS, but usually people who spend more time at the building with SBS signs are most likely at risk of being affected. Due to complexity of SBS subject which is the reason that it is not classified as an identified sickness is that the signs and disorders disappear after twenty minutes to two hours as soon as the infected user leaves the building; that is the reason for building being called as sick, not the affected users (Jansz, J. 2011).

1.1 Problem Statement

People spend a lot of time in buildings where they live or work, therefore it is important that the building provides a proper condition for the users. However sometimes buildings may not fulfil the requirements and conditions of a healthy environment for their users. Sick building syndrome is one of the main reasons for the mentioned issue. Many people are suffering from SBS issue in sick buildings, although it is not always easy to point out the causing problems. SBS signs can be observed in different situations and buildings, for example students feel sleepy at university classrooms or library, or workers do not feel good at their office because of different problems derived by SBS and as a result their performance and productivity decreases (Burge, P. S. 2004).

The problems related with SBS are serious and have negative effects on users, their health and productivity specially on educational buildings and schools, however mostly there is not enough knowledge and consideration about the subject amongst the users of buildings like students and lecturers and even architects and constructors, so victims usually are not aware of what they are suffering from and they either ignore it or visit a doctor which might not lead to a certain cure because the problem is related to the building not the body function.

Another important concern is that architects and constructors are mostly focused on sustainability issue which is also an important issue according to natural resources consumption crises , but the techniques and methods that are being used in order to obtain sustainability like less openings and tighter buildings sometimes leads to creation of SBS (Marmot, M. G. 2006).

1.2 Aims and Objectives

In today's competitive world, having the maximum productivity and reaching to the maximum capacity is essential either at working places, schools or even at homes and this is not possible unless the buildings can perform well and provide the required conditions for the users. Sometimes buildings fail to provide the needed requirements for users because of SBS problems.

The schools and educational buildings have special indoor conditions affected by different variables, like the number and age of users, different activity types, indoor air quality, visual comfort, acoustic problems and psychological condition of the students (Goyal and Khare 2009).

The effects of SBS is even more important at this kind of buildings as it affects the

productivity and learning capacity of students. This research is analyzing a selected case studies (EMU, colored building A18 and A27 classrooms) which are suspected to be affected by SBS, to find out if the students are suffering from SBS signs, discover the causing elements of SBS and propose solutions which can solve the problem, increase the capacity and productivity of students and increase the awareness about the issue among students and lecturers.

1.3 Research Methodology

A mix of qualitative and quantitative approach is used to do this research as the study includes observation and building analysis and distribution of questionnaires. The selected case studies are A18 and A27 classrooms at Color Building of EMU Faculty of Architecture. These classrooms have been selected according to their physical condition, indoor air quality and sun direction that they are receiving (west side) which makes it more likely to be affected by SBS signs; the selected classrooms also have the same condition, they have same plan type and sun direction but in different floors so the results derived from one will be also proof for the results of the other classroom and make the collected data more clear. At each classroom 150 questionnaires distributed among all the students who use these classrooms in different courses.

1.4 Limitation of the Research

Sick building syndrome is a very wide and complex issue; there are many factors that might create this problem which needs expert analyzes and specialists to examine the building and point out all the problem, but effects of these symptoms can be clear on users. There are many different classifications for SBS in different researches, this study is focused on the most common factors which are present in most of the classifications suggested in literature and limited on educational buildings and also according to conditions of the selected case studies and are more relevant to the

situation which are building dimensions concerning the activities taking place in the room, quality of indoor air, lighting and visual comfort, acoustic of the space and psychological conditions. By investigating these factors and observing the users condition while they use the building and asking questions from them by questionnaires and interviews it will be clear if the selected cases can be listed as sick building, and propose proper solutions in order to fix the problem and create a safe environment for students so they can have their maximum productivity at their courses being hold at the selected classrooms.

1.5 Structure of the Research

This research is formed by six chapters. Chapter one is about general information about Sick building syndrome and importance of the issue, defines aims and objective of the research, and explains the methodology and limitations of the study.

Chapter two is about general classifications of illnesses within a building with more focus on SBS, explaining a brief history about the subject, and continues with definition of SBS, who can be affected by it and what are the economic consequences derived by this subject.

Chapter three is about the most common factors and causes of the SBS, it covers different factors which create different symptoms and how each of these factors affect the users.

At chapter four, after understanding the subject, and problems derived from it the possible preventions and solutions for the problem is discussed with focus on educational buildings.

Chapter five includes investigations and analyzes on case studies to point out the possible signs of SBS according to factors covered in previous chapters and continued with results and possible solutions towards the problems existing in the case studies.

The chapter six which is the final chapter concludes different points of view about the subject and suggests possible in order to reduce or eliminate the SBS symptoms and increase the productivity and comfort level of the users.

Chapter 2

ILLNESSES WITHIN THE BUILDINGS AND SICK BUILDING SYNDROME

Buildings are supposed to preserve and protect the people who are using it. People live and work inside buildings so they spend most of their lives in the buildings. They need a safe and healthy condition in buildings whether to perform well in their jobs or live a healthy and relax life at their homes. Sometimes buildings fail to provide this condition for the users due to different reasons which is discussed at this research. At this situation they call the building 'sick', however a building cannot actually be sick, but the condition that it provides as indoor environment might be affected by pollutants and other factors which might cause to sickness for people who are using it (Greer C. 2007).

There are very different factors and details which may cause to creation of illnesses within a building. But there is also a more general outlook towards the causing factors, one of the main concerns is excessive attention for sustainability subject.

Designing energy efficient buildings are the main focus among the architects in order to save energy which is a major concern these days. Certain strategies are being used to achieve this goal like increment of insulations, tightness of building structure and less amount of openings in order to loose less energy. The problem with these strategies is that although they save energy, but sometimes they also lead to discomfort

and unhealthy conditions which is causing to occurrence of Sick Building Syndrome (Murphy M .2006).

2.1 General Classifications of Illnesses within the Buildings

There are different classifications of illnesses within buildings in different studies. For example Sumedha M Joshi divides the illnesses as listed below:

- SBS or Tight Building Syndrome.
- Building-related Disease, when the symptoms of diagnosable illness are identified and attributed directly to airborne building contaminants.
- Building-associated Symptoms (Joshi, S. M. 2008).

Jack Rostron, who is a lawyer and licensed urban planner, has significant studies about different aspects of Sick Building Syndrome. He separates illnesses within the buildings to four kinds. It is important not to confuse and mix these terms along the process of diagnosing the problems that might exist and choose a successful and correct solution accordingly and improve the conditions (Passarelli, G. R. 2009). Here are four kinds of illnesses:

- Building-Related Illness (BRI)
- Mass Psychogenic Illness (MPI)
- Neurotoxic Disorder (NTD)
- Sick Building Syndrome (SBS) (which is discussed at this research).

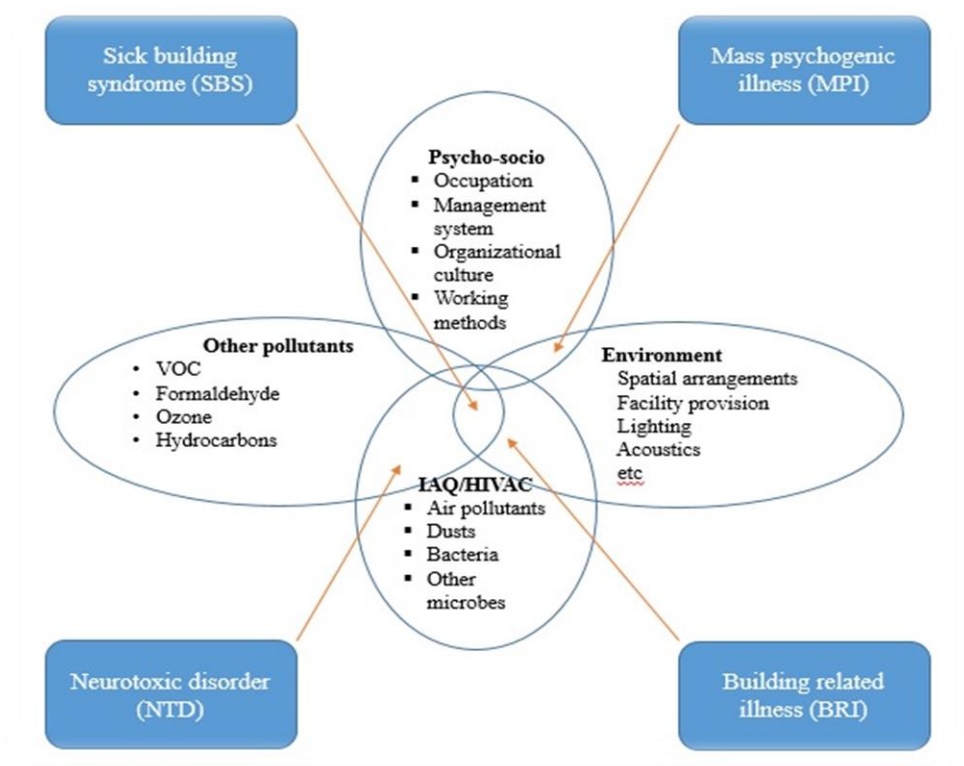


Figure 1: The workplace related illness model (Gomzi, M., & Bobić, J. 2009)

2.1.1 Building Related Illness (BRI)

Building related illness is defined as set of diagnosable disorders and inconveniences which symptoms and reasons of it are directly linked with exposure to chemical, biological and toxic materials within the buildings.

BRI is a significant issue nowadays like SBS due to change of life style that has been accrued since 1990s which inhabitants of large and modern cities spend near 90% of their time during the day in indoor environments like their working places. Nowadays competitive economy and business condition requires employees with maximum health and productivity in order to loose less money and time which makes it crucial to have a safe and standard space and indoor air conditions (Bousquet et al. 2008).

BRI diseases and symptoms are quite homogeneous clinical issues, objective lab irregularities, and a number of recognizable motives and causes which may carry illnesses and disorders with infection and allergic repercussions (Menzies and Bourbeau 1997). Some of the common disorders related to BRI are disorders in eye, nose and throat, humidifier fever, chest tightness and muscle aches.

2.1.2 Mass Psychogenic Illness (MPI)

According to Colligan and Murphy MPI is 'the collective occurrence of a set of physical symptoms and related convictions, without a distinguishable cause'. MPI has similar perspectives with the other disorders (SBS, NTD and BRI). the most common indicators of MPI are:

- work intensity
- mental strain
- work/home problems
- education
- sex

Mass Psychogenic Illness occurs when large number of individuals in a building or environment are infected or admitted to be affected by number of symptoms, but there is not a recognizable infectious factor for the issue. MPI shares similar signs and features to other work related environment sicknesses.

MPI often does not happen through a particular sickness, it is related to psychological factors. People who are influenced by MPI might suffer from extreme pressure and tension in their working environment. MPI and sick building syndrome are similar at

some points but have some differences as well like the signs and effects of MPI do not decrease or disappear when the effected person leaves the building or area, and the roots of this "sickness" is often by social networks, not by conditions or problems derived by building or environment (Rayner, A. J. 1997).

2.1.3 Neurotoxic Disorder (NTD)

NTD can occur to individuals who are in proximity of neurotoxic materials like combination of organic solvents and heavy metals, which can lead to disorders like mental slowing, difficulty in concentration and mood changes.

The difference between NTD and SBS is that in NTD both physical and psychological symptoms are pronounced. Although NTD might give away an analogous psychological reaction to SBS, especially if the problem and solution for it is delayed or ignored (Hartman, D.E. 1988).

2.2 History of Sick Building Syndrome

In 1970s, it was perceived that general symptoms of SBS were checked for by residents in new constructed homes, workplaces and nurseries. It was called "office illness" in social media. The phrase "sick Building Syndrome" was written in 1986, when they found out that 10-30% of recently built office buildings had indoor air issues in the West (STENBERG, B. 1994).

Poor indoor space have been taken into consideration. The Swedish allergy study, as was trembled, pointed "sick building" such a reason for the allergy epidemic. Together with these lines, in the 1990s, extended study was done in "sick building" subject. Various chemical and physical elements in the buildings were found on a vast front.

The point continuously was underlined in media. It was characterized as a "ticking time bomb". Huge number of studies and tests were done in buildings.

In the 1990s the phrase "sick buildings" were comprehended against "healthy buildings". The chemical fabric of building substances were pointed out. Most of building material producers were trying to take control of the chemical substances and to displace reproached added loads. The ventilation businesses were attracted to more suitable and adequate ventilation. Different solutions was being offered like using natural materials, ecological construction and basic methods (Rylander, R, 1997).

Near the end of the 1990s a developed suspicion appeared about the concept of "sick building". An interpretation at the ‘Karolinska’ Institute in Stockholm analyzed the previous research system, and a Danish revisal from 2005 experimentally illustrated these conflicting ideas.

They claimed that Sick Building Syndrome was not basically a clear syndrome and it might not be perceived as a definite identified disease. In 2006 the Swedish National Advisors of Health and prosperity designated in the medicinal record Lakartidningen that "sick building syndrome" should not be used as a clinical appraisal. After that, it has appeared to be less normal to use phrases like "Sick Building Syndrome", and "sick buildings" in studies and researches. In any situation, the idea stands alive in pop culture and is used to give the composition of symptoms in connection with problematic working or living environment. Therefore "Sick Building" is a term used to consider working space health.

At late 1970s 'energy crises caused the buildings to be more energy efficient regarding to the big increase in energy use and as a result increase at energy prices. This condition made architectural methods to be concentrated on design buildings like offices, to be 'air-tight', this leads to energy efficiency as there is less thermal loss inside the building inside the buildings.

2.3 Sick Building Syndrome

US Environmental Protection Agency defines SBS as circumstances in which building inhabitants suffer from intense unhealthy and discomfort symptoms that seems to be connected to time spent in the building, yet no particular disease or cause can be recognized. The issues might be restricted in a specific room or zone, or might be broad all through the building. The SBS signs that may happen separately or in blend with each other are headache and dizziness, eye, nose, or throat burning, caught, skin problems, trouble in concentrating, tiredness and being sensible to smell (Redlich, C. A., Sparer, J., & Cullen, M. R. 1997).

The qualities related with SBS might happen in any building where certain conditions exist. SBS symptoms has mostly been seen in post-war constructed buildings that offer the mutual affecting characteristics. These characteristics includes buildings that are mechanically ventilated; poor or wrong design layouts, lack of active maintenance arrangements; and have improper furnishings and building materials.

The ‘American Standards for Heating, Refrigeration and Air-Conditioning Engineers ’ (ASHRAE) claims that when 20 percent or more of its users report or complain of disturbance symptoms for more than two weeks and infected users relieve from

reported symptoms shortly after they are away from the building the building can be called as sick ' (Jansz, J. 2011).

2.3.1 Effects of Sick Building Syndrome

Those users of a building which is classified as a 'sick building' might suffer from an amount of general symptoms that are not related to each other All contaminants and affecting components and conditions have diverse structures. Therefore, affects and influences on humans are different as the causes and factors are different. Diverse contaminants leads to distinctive risks in various individuals (Wargocki, P. Wyon, D. P. 2000). The possible impacts of a given contaminant or pollutant on people forms the risk. Problems caused by various contaminants and different variables happen diversely relying upon the biological and psychological condition. The dosage of the contaminant present in air along with time spent in affected building is another components that specify the intensity of the health effect.

A number of organizations have made attempts to recognize and separate the different symptoms and try to categorize them according to categories, which is related with microbe or chemical, yet the these characterizations and classifications have not been officially announced. Roston (1998) breaks up the symptoms of SBS into five common groups which are listed below.

1. 'Mucus Membrane Irritation – influencing the nose, eyes, and throat': the most usual discontent in sick buildings is obstructed or 'stuffy' nose, and sneezing and running nose is the less frequently seen case. Annoyance of throat, increased thirst and dry coughs may also appear. This could make more issues to people who are sensitive to the impacts, that is, issues for the ones who use contact lens.

2. ‘Neuropsychiatric annoyance, like dizziness, lack of concentration, confusion exhaustion and headache’: The headaches which occur at this condition are explained as a usual heavy pressure on the head, and often do not expand into throbbing headaches or migraines.

3. ‘Skin agitation, like dryness and itchiness: as these symptoms they take place over long period of time and could simply be joined to other elements or medical conditions they are the hardest symptoms to relate to SBS.

4. ‘Asthma-like symptoms, like breathing problems and tight chest: weak indoor air qualities with a large amount of airborne dusts might make up troubles for residents without any health problem. This situation may even increase and aggravate current problems that individuals with medical conditions may experience.

5. Undesirable odour (smell) and taste senses: diffusion and radiations from products which are being used in closed spaces may be distasteful for inhabitants and it might cause to nausea.

Different theories and reports claim that more than 50 different symptoms might be recognized in total that might happen without any attention, which might add to main issues and problems (Raw, G. J. 1992).

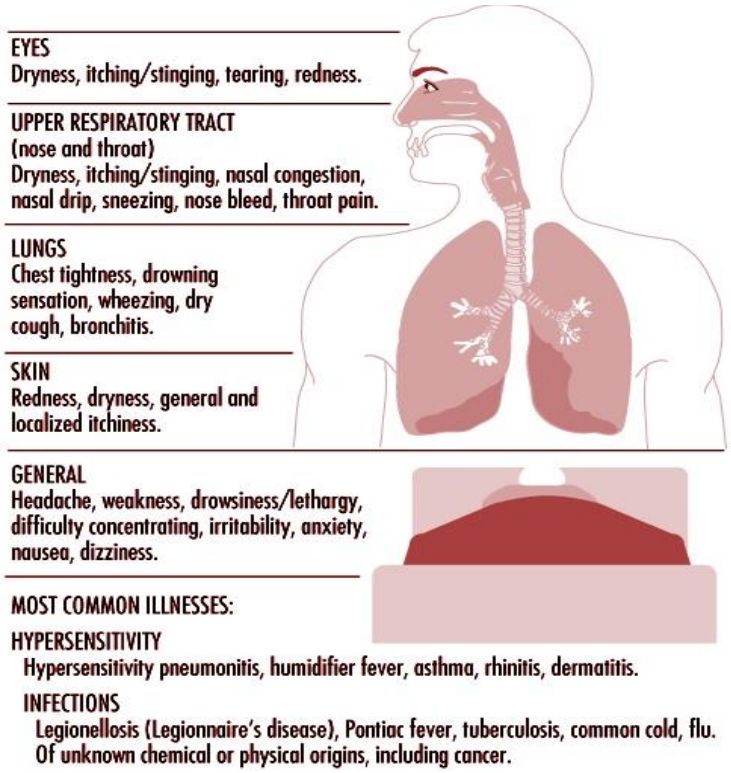


Figure 2: Effects of SBS on human health (Berglund, B, 1992)

2.3.2 Risk Groups of Sick Building Syndrome

SBS does not recognize a distinction; it might influence any individual who is present at the zone or building that is suspected to be a sick building. Building occupants specially employers must pay attention and be conscious about the signs and symptoms of SBS, regardless of the fact that these signs and symptoms might not necessarily influence everybody in the building or company.

Lars Molhave one of the researchers of SBS has done a study about risk groups of SBS. He claims that impacts of SBS might be seen as an outcome of a protective reactions of body that is depended on the environment condition that people are living in it. He also states that human reaction towards the situation of environment is connected to a biological model that includes three levels as listed:

Sensory perception of the environment: The senses consist of, taste, chemical sense and odour. The chemical sense points to the nerves on the skin and in the mucosal crust (mouth and nose) that responds to chemical provocation. Function of the senses results to annoyance and probably a preservative reaction like sneezing.

Poor inflammatory responses: Instigative responses are associated to metabolic and microbiologic reactions and in general are regarded to be a preservative response to promising cell injury. Critical, reversible reflexes are related to being in presence of low-level contaminants in non-industrial spaces like working environments.

Environmental stress reactions – The continuous attempts in order to recognize desired sensory and to repeal the undesired sensory information, and the attempts in order to preserve protective reactions could lead to lateral effects like headaches (Baechler, 1991).

Complaint ratio of different SBS symptoms are different in various groups. According to researches, women tend to complain more than men about effects and discomforts of SBS. Also people with low job satisfaction usually seem to report more symptoms according to others. But there is no obvious reason behind this issue; women might have more tendency to complain about sicknesses and disorders, or employee with lower job degree might spend more time in their working environment in compare to others. These are some of the reasons that makes identifying and solving SBS even harder because the evidences and solutions are not absolute (Hodgson, M. 2002).

2.3 Economic Consequences of SBS

Quality of the environment has a direct impact on increasing or decreasing of the productivity of the users. Sick building syndrome is a main concern when it comes to space and environment quality; the issue may cause to serious economic consequences in companies and working environments from different aspects like calling sick because of SBS effects, reduce of working productivity, and the costs that is needed to avoid or solve the SBS problems. According to submitted documents to the UK parliamentary committee on the environment, the expenses caused by SBS in a large scale government office including 2500 users has been estimated assuming that one day of absence in each year , and an hour for each month is directly or indirectly related to complains about indoor environment (Fisk, W. J. 2000).

SBS signs can be considered as an obstacle to work and lead to being absent from work and visiting to doctors. It is needed to investigate and do some maintenance activities when symptoms of SBS become specifically problematic. These investigations require financial support and also a lot of effort to be used by the staff of the construction management, safety staff, and also by construction engineers (Colton, M. D., Spengler, J. D. 2014).

Responding to SBS symptoms consists of expensive reforms in the buildings, like changing in its carpeting or removing all coverings of the walls in order to delete the molds, changing lighting system, enhance acoustic condition, and also the ventilation system of the building may be changed and etc. In several cases, SBS resulted in lengthy and costly litigation. Obviously, reaction to SBS symptoms leads to some costs imposed on society though the process of quantifying this type of cost is not clear.

Annual Economic Impacts				
Contaminant-Related Health Effect	*Health Care Costs of Effects due to Work or Non-work Exposure*	*Costs from Absence due to Illness & from Other Performance Losses due to Work or Non-work Exposures*	*Estimated Economic Consequence for Indoor Workforce due to Work or Non-work Exposures*	*Estimated Economic Benefits Possible from Improved Indoor Work Environments*
Communicable respiratory infections: building-influenced, occupant sources (e.g., influenza, common cold, tuberculosis)	$10 billion in health care costs	$19 billion in absence from work; $3 billion from reduced performance at work	$32 billion	$3 to $4 billion (estimate has substantial uncertainty)
Asthma, hypersensitivity, pneumonitis, and allergic disease, building related	Asthma, $2.6–$2.8 billion; allergic rhinitis, $580 million; other, not estimated	Asthma, $340 million; allergic rhinitis, $377 million; other, not estimated	$3.9–$4.1 billion	$200–$600 million (estimate has substantial uncertainty)
Nonspecific building-related symptoms (acute effects of indoor exposures or conditions, including SBS)	Unknown (effects from work exposures only)	$20–$70 billion (effects from work exposures only)	$20–$70 billion (effects from work exposures only)	$4–$70 billion (estimate has substantial uncertainty)
Respiratory infections: building sources (Legionnaires' disease, Pontiac fever, fungal infections)	Legionnaires' disease: $26–$40 million in health care costs; Pontiac fever: minimal health care costs; fungal infections: unknown costs	Legionnaires' disease: $5–$8 million in absence from work; Pontiac fever: unknown absence costs (1-week/case); fungal infections: unknown costs	Greater than $30–$50 million	Tens of millions of dollars

Figure 3: Annual economic impact of SBS in US (Colton, M. D. MacNaughton. 2014)

It is estimated that the charges of a small decrement in productivity related to SBS symptoms are probably more noticeable than the costs of SBS in total. There is a little information in the history of architecture to show the impact of SBS symptoms on the productivity of workers. In an investigation made in New England which was explained in the US 1989 report to the congress by Environmental Protection Agency, it was shown that the loss of productivity based on their self-reports affected by poor indoor air quality was 3 percent on average. Woods et al in a telephone investigation of 600 office workers in the US found out that 20 % of them were dissatisfied because their productivity was hindered as a result of indoor bad air quality; however, the investigation didn't show the amount of decrease in their productivity. Raw et al making a survey on 4373 workers in offices in the US whose SBS symptoms were high in the previous year found that bad working condition had a bad effect on the productivity. On average, the amount of self-reported decrease the productivity of all

workers, consisting of those who had no SBS signs, was nearly 4 %. In another experimental study, the workers for whom ventilation systems were controlled individually reported fewer SBS symptoms and indoor air quality in their workplaces improved up to 11 % relative to a productive decrement which reached 4 % due to controlling the population of workers (Menzies, D., & Bourbeau, J. 1997).

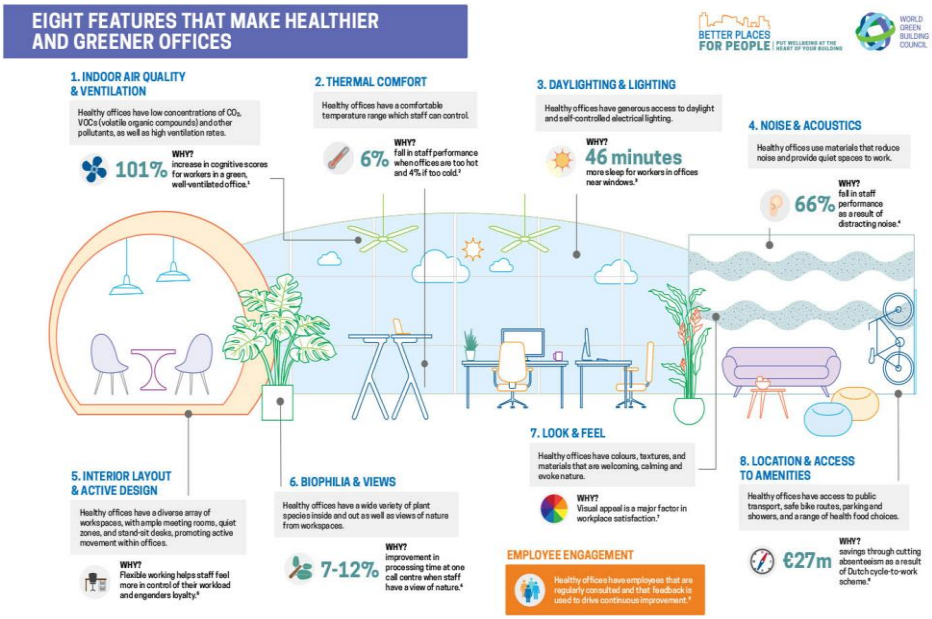


Figure 4: Eight features that make healthier offices (Schwartz, S. 2008)

Besides these decrements in self-reported productivity, Nunes at 1993 provided measured data about the effect of SBS systems on the performance of workers. The length of response time for workers who did not report any SBS symptoms was 7% more on a computer-based neurobehavioral test and the rate of errors in this test had a non-significant decrease. The rate of errors for workers with SBS symptoms was 30 % higher but the length of responding time was fixed.

On average, the percentage changes from four performance results reflects a 14 % reduction of the workers with SBS symptoms. When it is multiplied by the calculated

23% of workers who have two or more common symptoms, a 3 % average decrement in performance is observed.

Calculations of the loss of productivity due to SBS symptoms is based on the limited information which is at our disposal. The objective data which was reviewed up to now show that SBS symptoms are in connection to decrements on the order of 3% to 5% in special aspects of performance averaged in population; but it is not obvious how translating of the special performance decreases is possible (for example rises in response times and the rate of errors or falls in typing performance) with the large degree of total decrease due to SBS symptoms. About 4 % productivity decrease has occurred due to poor quality of indoor air and physical situations at a work place. Though SBS symptoms problem is believed to be the most usual health concern in working places, some self-reports of the workers in the subject of productivity decrease may be the result of some factors except for SBS symptoms. In addition, the workers who are not satisfied may have exaggerated about their estimate of productivity decrements. In order to account for such factors, the 4% productivity decrement mentioned above will be discounted by a factor of two, resulting in an estimate of the decrement in productivity which is made by SBS (Bas, G. S. D., Weibach, W. 2005).

SBS symptoms are mainly in association with office buildings and indoor working places which are not industrial e.g. schools. According to Traynor et al, the workers in the offices are responsible for almost 50 percent of the yearly gross nationwide products in the US. Statistical data about the civilian work force occupations matches with this estimate roughly; in other words, 50 % of work force have occupations which

are usually referred to as teaching or office working. As the gross domestic product in the US in 1996 was $7.6 trillion, the gross domestic products related to the type of office working is nearly $3.8 trillion. When one multiplies the number of workers in offices and the teachers (64 million) by the average yearly compensation for whole workers ($39.2 K), the result is a similar amount of $ 2.5 trillion. When one calculates the average of these two estimates, the result is $3.2 trillion. According to the 2% productivity decrement made by SBS symptoms, the yearly national costs of SBS symptoms is on the $60 billion order (Traynor, G. W., Talbott, J. M., & Moses, D. O. 1993).

2.4 Chapter Summary

Generally illnesses within the buildings are divided to four categories: Building-Related Illness (BRI), Mass Psychogenic Illness (MPI), Neurotoxic Disorder (NTD) and Sick Building Syndrome (SBS) which is the focus of this chapter. The common characteristics between the mentioned illnesses is that a number of individuals who work, live or study in a close proximity to each other suffer from a number of similar symptoms which is related to the environment and existing of possible inconvenience and pollutants. But they have differences as well, unlike SBS, the causes for BRI are identifiable but they do not disappear after leaving the building. MPI is only related to psychological factors unlike SBS that covers physical disorders as well, and there is no relief of symptoms after leaving building. NTD is not effected by psychological and gender variables like SBS.

SBS happens when 20 percent or more of occupants of building suffer from symptoms such as headache, dizziness, eye, nose, or throat burning, caught, skin problems, trouble in concentrating, tiredness and being sensible to smell and the effected user

relieve from symptoms shortly after they leave the building. Despite the health problems of SBS, the economic impact of SBS is a very important issue as well which leads to huge costs for organizations if they do not pay attention to issue, and on the other hand, solving or preventing SBS can have huge positive effect on economy.

Chapter 3

CAUSES OF SICK BUILDING SYNDROME

Many studies has been done in order to point out the conclusive causes of SBS but there is not any absolute conclusion or result to the issue yet. The occurrence way of the symptoms which is during the working day and week arises the feasibility of the problem being an infection. Physical environment should also draw attention and be taken into account as it is a crucial subject. There might be various causing elements to SBS in various buildings (Redlich, C. A. 1997).

Many different factors and causes has been proposed in different studies for SBS, which most of them are centralize on quality of air quality and ventilation system. There are also some common factors which are discussed and mentioned in most of the researches as the main contributing factors which lead to SBS which are listed as below:

- Spatial and dimensional features
- Indoor air quality
- Visual comfort
- Acoustic and noise comfort
- Psychological factors

3.1 Spatial and Dimensional Features

Biological, sociological and psychological needs of humans are depended on their actions, which take place inside buildings that needs a certain size of area, dimensions and shape according to the type of action. The building spaces, dimensions and components must be according to dimensions of human body.

This relationship should be according to static and dynamic anthropometry. Static anthropometry refers to dimensions of the human body in an upright and stable condition and dynamic anthropometric refers to dimensions of body that are measured while executing particular actions (Toka 1989).

In order to design such a building the architect should consider the space and functions takin place inside, the required elements and equipment relevant with these actions and size and installment of them in the space and the needed field for usage of the equipment.

The form of space must be according to in the function taking place in the environment. It should express the mass and form of the structure and the recognizable characteristics. If architect fails to consider these points at design it is not going to be a suitable design for occupants and cannot satisfy user needs which can affect the health and comfort of user (Vural, S. M., & Balanlı, A. 2011).

Table 1: Health effects derived from spatial and dimensional problem (Vural, S. M., & Balanlı, A. 2011)

Sick building syndrome			
Feature Negative features of building		Health problem	
Space inadequate in Dimension dimensions for the needs	Crash	Ache Injury	Stress
	Constriction	High or low blood pressure Need of urinate Stomach and intestine movements (Ozttirk 1997)	
Space too large for the needs	Fatigue	Strength reduction	Stress Loss of concentration (Işıl 1991)
	Depression		Stress

3.2 Indoor Air Quality

The phrase indoor air often refers to non-industrial indoor spaces: public buildings, office buildings, and private residences. centralization of pollution in the indoor air of these buildings are often similar to arrangement as those usually discovered in outdoor air, but they are indeed less than the ones discovered in industrial structures air, where somehow popular standards are regarded for analyzing and checking air quality. However, there are lots of complains from building residents about the quality of they are breathing so there is a demand for analyze analyzing and investigating the circumstance. At the end of the 1960s, Indoor air quality start to be pointed to as a problem, there was no sign of researches about it till years after that (Sola, X. G. 1998).

The first serious studies and attention towards air quality started at 1970s mostly in European countries which was because of the oil crises at 1973. The main concern at designs of new buildings was to save energy consumption because of the oil crises, which caused to decrement of air conditioning systems which leaded to increase of indoor air contaminants and pollutions in buildings.

Sources of indoor air pollutants and their effects on health:

In order to peruse the origins of contaminants, constituent elements of atmosphere need to be studied. It includes oxygen, nitrogen, carbon, dioxide, and argon and small quantity of other gases. Air pollution happens when there is a change in proportion of these constituent elements. Changes in components of atmosphere results changes in indoor air quality (Table 2). Every indoor air contaminant has a diverse structure which comes from various origins. Each contaminant might cause to various health impacts with distinctive amount on different individuals. Large number organizations in several countries define the adequate levels for indoor air contaminants.

Table 2: Different pollutants and their effects on human health (Jones, A. P. 1999)

Pollutant	Sources of pollutant	Health effects
Gas and vapors		
Carbon monoxide	Vehicle exhausts Chimney Incomplete combustion Tobacco smoke Household chemicals	Headache Fatigue Lack of coordination and performance Breathlessness Weakness Dizziness Dimness of vision Vomiting Changes in pulse rate Confusion Changes in personality Coma
Carbon dioxide	Biological activities of people Chimney Incomplete combustion Tobacco smoke	Drowsiness Dizziness Headache Nausea Breathlessness
Nitrogen oxides	Vehicle exhausts Chimney Incomplete combustion Tobacco smoke	Burning and stinging of eyes, nose and throat Coughing Respiratory complaints
Sulfur oxides	Fuel and coal combustion	Burning and stinging of eyes, nose and throat Suffocation Coughing Increasing of respiratory complaints

Pollutants of air exist in all indoor spaces in the world. By breathing, swallowing and also by our skin we can absorb pollutants into our body. Many researches have been done on the effects of pollutants of outdoor but at the same time a large number of research reflected that the pollutants of indoor air are that much harmful too.

The Environmental Protection Agency in the US expresses that indoor pollutants are more dangerous than outdoor ones since the sources of outdoor pollutants are strictly observed in order to control making smog (photochemical ones) and particular matter. Some of the most usual types of dangerous indoor pollutants include nitrogen oxides, ozone, carbon monoxides, volatile organic compounds (VOCs) like formaldehyde, benzenes, and limonene. In schools, offices and similar residences, these types of pollutants may be the result of emissions from printers, rodenticides and pest, supplies for cleaning purposes, products for personal care, painting, and pollen and spores of fungus (Bayer, C. W. 1995).

The impact of each contaminant on users' health forms a risk. This risk is variable as the contaminants and their doses change. The alteration changes also according to biological and medical history of the users. For instance radon which is one of the indoor contaminants can have a more intense harmful impact on a smoker in compare to users who do not smoke (Daisey, J. M., Angell, W. J., & Apte, M. G. 2003).

3.2.1 Chemical Contaminants:

One of the common causes of creation of SBS is chemical contaminants which is consisting of two sections:

Indoor sources: There are two various origins for indoor contamination: the residents themselves; insufficient materials or the ones with technical faults having been used

in manufacturing a building; the work which is actually done in it; too much or incorrect use of usual products (disinfectants, pesticides, products for polishing and cleansing); gases which are the result of combustion (smoking, cafeterias, kitchens, and labs); and cross-contamination which is the result of poor ventilation of some places leading to diffusion of surrounding places and influencing it. It should be taken into account that a substance which is emitted in indoor air is less likely to be diluted than that of outdoor air simply because of the extent of air existing in each one. In terms of contamination made biologically, it can be said that its source can be stagnant water, substances which are impregnated with water, exhausts etc, and also can be the result of faulty maintenance of refrigeration towers and humidifiers (Redlich, C. A, Sparer, J. 1997).

Figure 5: Signs of molds and dampness due to indoor pollutants (Molhave, L. 2008)

Outdoor sources: Regarding human-related activities, there can be found three major sources: stationary sources combustion (power stations), moving sources combustion (like vehicles), and what is done during industrial procedures. These sources emit five major contaminants named carbon monoxide, oxides of nitrogen, oxides of Sulphur,

hydrocarbons as an example of organic volatile compounds, aromatic polycyclic hydrocarbons and particles. Combustion done internally in vehicles is the main origin of carbon monoxide and also hydrocarbons as well as being an important producer of oxides of nitrogen.

Stationary sources combustion can be considered the main source of Sulphur oxides. Industrial procedures and combustion related to stationary source produce half (even more) of the particles which are emitted into the air due to human activities and organic volatile compounds can be the result of industrial processes. Also, some contaminants exist naturally in the air such as volcanic dust particles, sea salt and soil, microorganisms and spores. Ingredients of outdoor air differ in different places due to the source of contamination itself in neighboring areas and due to the direction of the wind (Letz, G. A. 1990, May).

3.2.2 Volatile Organic Compounds (VOCs)

VOCs are chemicals which usually related to IAQ s. Volatiles are chemicals that their vapor pressure is high and have emission of gas into the air and they are the result of making materials, products related to consumers, paints, products of personal care, furniture, and so on. A lot of research have proved that outdoor air pollutants create bad respiratory effects on health but the recent studies reflected that indoor ones may lead to similar results. For instance, a lot of exposure to indoor ozone leads to heartbeats which are irregular and poor performance of lungs and also irritation of eyes, skin, nose, throat and nose (Molhave, L. 2008).

The density of indoor pollutants in some cases are demonstrated to be twice in comparison to outside ones. Pollutants in indoor air has continuously led to asthma, allergies, and bronchitis. Surveys on indoor pollutants in places which serve food to

people have found that here is a positive relationship between VOCs, PM, polycyclic hydrocarbons of aromatic products (air pollutants made during broiling meat and fuel burning) and inflammation of kidney. Also allergic reactions can occur as a result of these pollutants between non-sensitive and sensitive people (Apte, M. G. 2000).

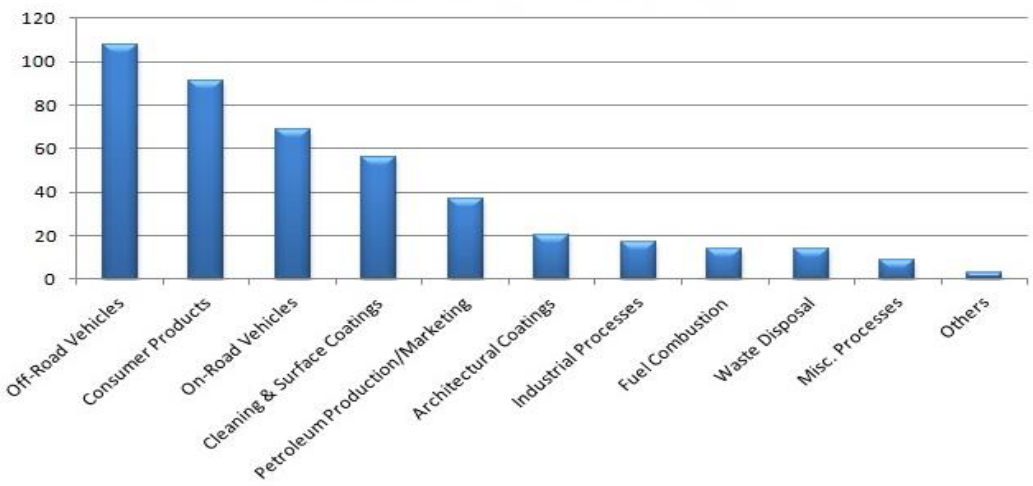


Figure 6: Major Source of VOC Emissions (DeMaria, K. 1999)

3.2.3 Odours

Odors are considered organic or inorganic mixtures that their origin is inside the building or from the outdoor. Odors with indoor origin relate to construction, furnishing, household, equipment of offices, bad ventilation, mould problems, bio effluents and so on. Odors lead to problems in environment quality of buildings. Based on the Report of European Commission about SBS, the main reason for SBS are hidden olfs of systems and materials (Gallego, E., Roca, X., Perales, J. F., & Guardino, X. 2009).

Figure 7: Signs of molds and bacteria which causes to bad odour (Gallego, E., Roca. 2009)

The next problem in quality of indoor air is smell as a crucial factor. Combination of a special smell and some irritating impact of a compound inside a building results in calling the quality of an environment as “fresh” and “clean” or as “polluted” and “stale”. So smell is an important factor when we define an indoor air quality. Odors are the result of existence of a compound higher than its olfactory threshold in an objective tangible way, but they are often evaluated subjectively. It should also be taken into account that we may perceive an odor from various compounds and its characteristics may be affected by humidity and temperature. Defining and measuring odors are based on four features: tolerability, intensity, threshold and quality. However, indoor air can’t be measured chemically so we tend to eliminate bad odors and use good ones instead. But this attempt usually does not work as odors can be perceived separately and result in unforeseeable (Engvall, K. Norrby, C. 2005).

Adults’ perception of odors or humidity associates with some environmental risk factors inside buildings. Among the most important ones (risk factors) are the following: dampness, living beside a main road, redecoration of buildings, new furniture, cockroaches, rats, mosquitos, flies, and the use of incense for repelling

mosquitos. Protective activities include more cleaning and exposing bedding to sunshine. All kinds of SBS symptoms, whether “weekly” or less usual symptoms, associate with odors and humidity though the symptoms related to “weekly” were stronger. In the odor group, the relationship between SBS symptoms and new furniture, cleaning frequency and dampness was stronger but in the non-odor group the relationship between it and insects such as cockroaches or mosquitos was stronger.

3.2.4 Environmental Tobacco Smoke

More symptoms can be observed in non-smokers who are forced to work with smokers than those who work in a clean, free of smoke place. The most exposure to tobacco smoke for non-smokers usually takes place in working places. A study showed that the symptoms reduced when there was no smoke in the working environment. Some other studies did not show an influence of cigarette smoke on symptoms; but there was no separation of non-smokers and smokers and the amount of exposure in working environments were low (Mizoue, T., Reijula, K., & Andersson, K. 2001).

Environmental tobacco smoke (ETS) is a complex and dynamic mixture of too many compounds consisting of many irritants, and it leads to serious symptoms of SBS, for example eye, throat and nose irritation. Studies have shown that exposure to ETS is a main determinant regarding SBS when in a working place the number of smokers is high and smoking restrictions are few. This finding is consistent with the previous findings which showed that bartenders are observed to have a marked reduction of symptoms related to sensory irritation when smoking restrictions are imposed in bars. One can also generalize this finding in similar working places i.e. when we set strict rules for smoking in workplaces, ETS lessens to the extent that it is not significant any more to result in SBS (Apte, M. G., & Daisey, J. M. 1999).

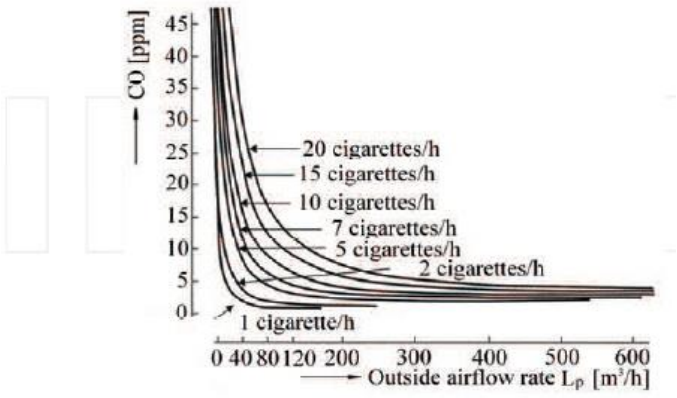


Figure 8: Effect of cigarettes on CO level (Mizoue, T., Reijula, K., & Andersson, K. 2001).

3.2.5 Ventilation

Ventilation is needed for a building in order to make fresh air come into the building from outside and dilute pollutants produced by occupants like CO2 and pollutants made by products like VOCs.

If ventilation is done mechanically, it is done by bringing in outside air, filtering it and delivering it to the residents. Even in good ventilation, the amount of indoor pollutants is higher than that of outdoor ones. Outdoor ones can come inside via different ways, like via the mechanical system in case there is not proper filtration of air stream. As people are inside most of time (99% for most of people), a lot of exposure to outdoor air pollutants happen indoor. Ventilation also affects humidity, temperature, and air pressure. To ensure of Indoor Air Quality (IAQ), present ASHRAE standards needs at least 20 cubic feet per minute for each resident. “Acceptable” amount for indoor air quality though research for decades has shown that ventilation rate should be higher. Besides high rate of ventilation, maintenance of HVAC should be improved as substandard version of ventilation often happens in the places in which HVAC systems are either overlooked or incorrectly maintained (Fisk, W. J., Mirer, A. G., & Mendell, M. J. 2009)

When ventilation level is low, quality of air is reported as unpleasant or stuffy. Such air not only makes people work uncomfortably, but also causes ranges of illnesses. These harms' symptoms can be fatigue, headache, and sinus congestion, shortness of breath, coughing, nose, eye, skin, throat irritation, nausea, and dizziness.

A lot of research has shown that students or employees who work in places where there is an adequate circulation and distribution of fresh air, have a higher level of productivity and health in comparison to those who spend time in places with poor ventilation. A research done in California schools has shown that students' concentration span is longer and they felt calmer in classes with high rate of ventilation. Poor level of ventilation had an association with more absences, less productivity, and high rate of operations cost. In offices, a relationship was found between low ventilation and high cases of short-term sick leaves, respiratory infections, asthma, among building residents (Joshi, S. M. 2008).

Poor quality of indoor air does not only affect users' health, it affects the productivity of users' as well. The development of indoor contaminants increases the absence amounts as it increase the possibility of SBS. Proximity to indoor contaminants like VOCs and carbon dioxide may directly affect psychological capacity. According to a 2009 meta-analysis consisting evaluation of the financial and societal expenses of damages related with IAQ, including decrement of productivity, health expenses, and building damages, the air pollution costs were estimated annually about 10 million dollars. On the other hand a healthy and clean indoor environment makes huge positive economic effect. For example in United States the benefits resulted from savings and productivity increment were estimated between 20 to 160 billion dollars per year (Wargocki, P. Wyon, D. P. 2000).

3.3 Thermal Comfort

Thermal health is an expression suggested by the For Health team to be replaced and used instead of the narrow expression “thermal comfort”. The expression “thermal health” covers all effects related to thermal conditions suitable for health as well as morality considerations, so it goes beyond just the term “comfort”. Thermal comfort is under the influence of some objective factors like temperature, humidity, speed of air and also some other factors like the level of metabolic activity and clothing thermal insulation. (Ooi, P. L., Goh, K. T.1998).

A too hot or too cold environment may result in occupants reacting physically to it. Such a reaction can also have a greater impact on the staff who are more sensitive to excessive temperature which, in turn, leads to their further body distress

The best inside temperature is between 20-23 degrees centigrade in winter and 20-25 degrees in summer and the relative humidity should be 40-60 %. Headache and fatigue may occur in indoor temperature of above 25 and chills or influenza symptoms can be the result of below 18 inside temperature. Normally, the inside temperature of a building equipped with air condition system in Australia is set to be 22 degrees centigrade. Radiant heat of the sun coming via west or northern windows of a building in the afternoon can affect its indoor air comfort. The extent of comfort of the residents of a building is a subjective amount as people definitely differ each other in terms of their preference regarding warmness or coolness of an environment (Jaakkola, J. J. K., Heinonen, O. P., & Seppänen, O. 1989).

People normally have different rates of metabolism; some are fat and some others are thin; some workers are quite active during work but some others are desk-bound.

However, all people in a public building with air condition system are exposed to the same fixed building temperature regardless of their individual differences. There is a positive relationship between the amounts of humidity of a place and the feeling of warmness by the people residing there.

In high indoor temperatures, SBS syndromes, negative moods, rate of heart beats, respiratory problems, and also fatigue increases. Disease transmission is also affected by temperature and the humidity of a place as it is found that cold and dry places increase the spread of influenza virus as viruses stay longer in a drier and cooler environment since these two factors extend the shedding period of a virus. On the other hand, warm and humid places result in fungal growth and mold.

The Property Council of Australia has stated that extra humidity of indoor air leads to the following problems:

- fatigues, stuffiness, feeling headache and dizzy (especially when the relative humidity is more than 80 percent and the temperature is high at the same time
- suitable condition for growing micro-organisms, particularly when there is condensation;
- higher amount of "off-gassing" derived by construction materials, particularly about organic volatile compounds like formaldehyde

In the case of very low humidity levels, the following problems may happen: (De Dear, R. J., & Brager, G. S. 2002)

- Eyes, throat and nose dryness
- Higher possibility of shocks made by static electricity

- Increase in the rate of forming ozone
- Stability of some viruses like influenza
- Allergic reactions through asthmatics.

3.4 Visual Comfort

Light is one of the components of our natural surrounding environment just like water and air, and at the same time it is one of the parts of our man-made environment like buildings. The light that we use for facilitation of human activities is called lighting and it is controllable by technological instruments just like ventilation and heating.

Lighting relates to both total satisfactions in the inside building environment and the facilitation of visual operation. Insufficient lighting results in eye strains, headaches and the other symptoms related to SBS. Usually health problems created by wrong or poor lighting condition can be stopped once the user leaves the problematic building but eye strain problem continues and leads to long terms problems in eyesight.

3.4.1 Daylight and Lighting

Daylight is the result of sunlight whether direct sunlight or the reflected one and it is different in terms of both quality and quantity, depending on the time of day, weather and also season. The eyes of human are adapted phylogenetically in terms of spectral distribution and the extent of daylight; natural variations stimulates our vision's processes. Artificial light is usually uniform so it makes "boredom" in the structure of our vision also it creates "fatigue" sooner. Because of all the above-mentioned reasons, the best lighting for doing visual activities is considered to be daylight.

The daylight is important for humans in terms of these two considerations:

• Biological and physiological factors (the impact of biology of body on organisms)

• Psychological factor (emotion, mood, activity)

As far as possible, natural lighting is preferred as it not only improves the health and comfort of the residents but also reduces the costs we pay for energy. However, because of the special design of most buildings, artificial lighting will be required especially in the case of using the building during the period when there is no daylight (Skov, P., & Valbjørn, O. 1987).

3.4.2 Artificial Lighting

Artificial and natural light differ each other in terms of the distance between the receiver of the light (human in this case) and the sender (source of the light). As the natural light passes through the protective layers in the atmosphere and its dangerous particles are ripped off by the electromagnetic field of the earth, it reaches us in the form of a harmless light for our health while in the case of artificial light in which the distance between the source and the receivers (we and other living creatures) is much less, the received light has perceived no filtration and no absorption of the infrared and ultraviolet rays and other invisible waves of electromagnetic field, making it more hazardous for us.

Being exposed constantly to artificial light during night disrupts the internal "clock" of our body with the crucial role of maintaining the life cycle. Normally, body clock is in accordance with the natural light so when we use artificial light our brain can't be adapted to the surroundings and can't analyze whether it is resting or working time (Begemann, S. H. A., Van den Beld, G. J., & Tenner, A. D. 1997).

Figure 9: LED ceiling to simulate the sky and satisfy occupant circadian rhythms (Begemann, S. H. A.1997)

There are more studies on the influence of high exposure to lighting (whether frequency lights of full range or blue cold fluorescent light) and they showed that high amount of the second one leads to releasing great amount of cortisol from hypothesis gland which, in turn, leads to stress in humans while the same has not been reported in the case of exposure to the first type of light mentioned above. The other problems observed were reduction in the performance of rate of immune system, cognition of mind, also increase in the anxiety of children's ADHA. These bad effects of blue and cold lights of fluorescent caused German health minister to legally forbid utilization of this lighting system in some of the medical clinics and institutes. Also, it was observed that aggressive behaviors increased among citizens who were highly exposed to fluorescent light emitting from light poles in the street.

Few number of epidemiological studies determine lighting as a reason for SBS. Instead of field studies, experimental ones have been done to obtain evidence on the influence of light on humans and the variety of methods and conditions can justify the contradictory results (Oodith, D., & Parumasur, S. B. 2012).

3.5 Acoustic and Noise Comfort

Noise definition is as follows: “unwanted or annoying sound” which intrudes normal activities like work, sleep, and talk. Noise can come from outside sources like airplane, traffic of roads, train, snow blowers, lawn mowers, and operating large noisy equipment in a construction site. Inside a building, noise can be produced by mechanical and also system of HVAC, different equipment in the office, industrial machines, vacuum cleaners, or talk between occupants. Most of people have heard about noise-induced hearing loss induced by noise which means that being exposed to noise may have bad effects on our auditory system directly. It may lead to a range of other effects like communication obstacles, limited attention and concentration, and increasing fatigue and stress because of strain. However, some other non- auditory problems may occur due to noise exposure. For instance, in 2013 it was estimated that around 145 million people in US might be continuously suffer from noise levels which can lead to hypertension.

Office buildings rely on mechanical systems to provide ventilation, heating, cooling, and water for occupants. However, these systems can also lead to noise and vibration problems.

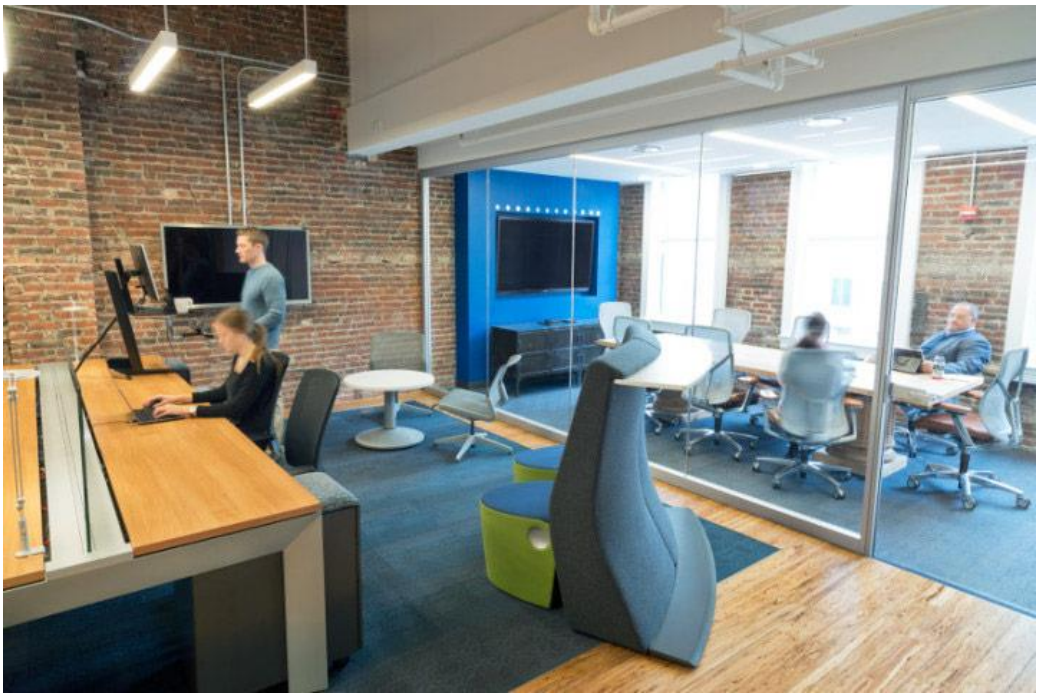


Figure 10 : Allsteel's Washington, D.C. office boasts excellent acoustic comfort (Schwartz, S. 2008)

Both high and low levels of noise can lead to SBS. According to the Academy of Otolaryngology, workplace noise that is consistently louder than 85 decibels (dB) similar to the sound level of normal conversation can be irritating and affect a person's health. Low-level noise is also an important risk factor for SBS. Several studies have shown that people complained more in areas where there was low frequency noise, for example, buzzing from fans.

Being exposed to noise may affect the function of many organs of body. Several researches about non-auditory influences of being exposed to noise have shown high noise level can increase blood pressure, change our heart beat and make hypertension. Exposure to noise of environment among children leads to emotional symptoms, increased hyperactivity, fatigue, higher blood pressure, irritability, behavioral problems, more stress hormones like adrenaline and noradrenaline, being unhealthy, and noise annoyance.

Noise annoyance is a kind of psychological stress including discomfort, frustration, distress, and irritation. In adults, transportation noise disturbance for a long time may lessen physical activity (Bourbeau, J., Brisson, C., & Allaire, S. 1997).

According to researches noise can affect reading and writing and exposure to noise can influence students' productivity. At 2014 studies proved that being exposed to environmental noise can directly affect students learning capacity. Also In offices and work environments, disturbing noise may decrease employee performance, whilr doing hard and complicated jobs. Poor acoustics can lead to different health problems related with SBS which is shown at figure 11.

			Sick building syndrome		
Feature	Negative features of building				
			Short term hearing problems	Temporary threshold shift Tachycardia	Stress
			Sleeping disorders	Fatigue Immunodeficiency disorders Tachycardia (Berglund and Lindvall 1995)	Mental disorders Distraction
Noise	Lack of noise analysis (internal and external factors, user needs)	Inadequate sound isolation	Stress	High blood pressure Nausea Dizziness Migraine Throat irritation Asthma exacerbation Itching Sweating (Berglund and Lindvall 1995)	Lack of concentration Anxiety Distressing Abstraction Nervousness Disquietude (Koknel 1997)
Acoustics	Insufficient room acoustic analysis	Reflection, absorption, propagation, refraction, reverberation, focusing and echo	Lack of hearing Inability to understand Inability to discern (Ozttirk and Balanh 1995)	Headache Migraine	Stress Acrimony Anger Nervousness

Figure 11: Auditory features of indoor environment and SBS (Vural, S. M., & Balanlı, A. 2011)

3.6 Psychological Factors

In the investigations on SBS, psychological factors were found only in long standing bad indoor air quality and in workplaces in which there was no health problems as air

quality was dealt with effectively. Greer (2001) confirms this finding mentioning that by reviewing literature he has found that psychological factors are symptoms of SBS not its cause and being exposed to some toxins cause embarrassment and bad mood.

A case study about "New and Refurbished Buildings" showed that the staff was accused of not wanting to get in the offices and their complaints were increased. It could be a psychosocial factor that may increase complains about problems employees perceive because they may not be satisfied with their facilities. When people are not satisfied or they are angry, it is normal to complain about factors that would be ignored in the case of their satisfaction (Gomzi, M., Bobic, J.2009).

3.6.1 Need for a Multifaceted Approach

The reason why there is no accurate "cure" is the point that these studies only consider one facet of the problem; therefore, a general solution can't be obtained. If the solution was just physical, i.e. IAQ, SBS would definitely be a matter of the past and the cure would simply relate to indoor air quality in order to identify the cause in a way that a course of actions to be recommended for eliminating the problem.

As not all aspects are taken into account in the investigations (especially psychological factors such as job satisfaction, focus of control and stressful workplace), the investigator (whether an academic one or a commercial one) may attribute the personal symptoms to physical problems. SBS is not a simple phenomenon as it includes not only physical problems but also psychological ones which will result in exaggeration of symptoms as well as susceptibility to symptoms via increased stress in working place as long as they are not recognized. Thus, both above-mentioned types of problems could be measured and investigated.

3.6.2 Psychosocial Dimension of SBS

Though the first causes of SBS symptoms may be a physical source, psychosocial structure of a building may affect the next happenings and relief of those symptoms.

Physical cause of a symptom will be easily solved if it is recognized at the right time but if the process of removing the problem is delayed, the symptoms can not only become severe by the psychosocial structure but also the eradication of the symptoms will be affected too. If one does not detect the problem in time, the only investigation of physical cause may result in an initial "cure" but symptomology will reappear unless one deals with psychosocial problems too.

A main incentive of expertise is the need to be in control not under the control of external forces. It is needed to feel free from restrictions and limitations. When one feels that his freedom is threatened, he tends to react by reassertion of his freedom i.e. expressing SBS symptoms and this is what is considered to be psychological reactance.

When one feels that he is restricted, he may produce reactance and as the time goes on, his reactions turn to "learned helplessness", i.e. the continued exhibition of SBS symptoms. Learned helplessness is a learned reaction in which a behavior has no effect on happening or not happening of an event. The impacts of learned helplessness are not simple but after positive reinforcement for a long period of time the reaction may change into a positive one and so the learned helplessness may be removed.

Generally, residents of a building tend to feel that they have no control over their working environment especially in the case of large and sealed building in which mechanical ventilation is performed and also there is a large open plan. It is normally

the case that working environment is set up before the arrival of its users or managers have already decided about all its factors in the limit of some legislation rules on its lighting, temperature, desk height, etc. It is generally felt by occupants that they have no control over their work place features and if they suffer from some SBS-related problems and try to question their working place environment and their request is delayed, then the problems will not only exist for them but become exaggerated (Bauer, R. M., Greve, K. 1992)

Psychological problems of SBS appear mostly in workplaces or educational buildings in which other problems like excessive work stress, dissatisfaction with job, high work load can intensify the SBS problems. SBS symptoms in terms of physical considerations cannot be eradicated by just looking at the physical aspects of a building. A systematic approach should assess everything including psychosocial considerations, adopting a good strategy and methodology in order to find a viable solution to decrease the risk of misdiagnosis and incorrect treatment interventions. Organizations that fail to investigate behavioral and psychological considerations and consider the issue as a simple environmental issue will probably lose significant amounts of money for eradication of SBS symptoms and instead of dealing with root causes their actions will, in turn, lead to continuation of SBS symptom occurrences (Soine, L. 1995).

3.7 Chapter Summary

There are very different causes and classifications suggested in different studies for causes of SBS. The most common factors leading to SBS are spatial and dimensional features, indoor air quality, visual comfort, acoustic and noise comfort and

psychological issues. Each of these factors are also divided into different parts and they have different effects on users' health which are summarized at table 3.

Table 3: SBS causes and their health effects (Made by Author)

Factors leading to SBS	Health Problems
Spatial and Dimensional Features	Injury, Stress, Lack of Concentration, Depression
Indoor Air Quality	Fatigues, Headache or dizziness, Shortness of breath, eye and throat irritation, Bronchitis , Lung irritations
Visual Comfort	Headache, Fatigue, Anxiety, Stress, Eye irritations, Increasing blood pressure
Acoustic and Noise Comfort	Headache, Nausea, Dizziness, Lack of concentration, Fatigue
Psychological Issues	Anxiety, Stress, Lack of Concentration

Chapter 4

PREVENTIONS AND SOLUTIONS FOR SICK BUILDING SYNDROME IN EDUCATIONAL BUILDINGS

Educational buildings refer to buildings that are designed for different teaching and learning activities in a primary, secondary, or higher educational system. Education gives the learning and abilities needed for human major advancement in any country. Studies have shown that the physical condition of schools and their facilities have a great impact in student's productivity and learning adequacy and behavior (Leung and Fung, 2005; Tanner, 2009). Building services like lighting, ventilation and acoustics are given in learning spaces to enhance health, comfort and security of the tenants, and encourage the learning procedure between the instructor's and students. Observational proof from past investigations has demonstrated that the quality of building conditions affects staff teachers and students health, comfort and satisfaction (Kok *et al.*, 2011; Leung and Fung, 2005; Uline and Tschannen-Moran, 2008). Also Simpeh (2013) claims that lighting, ventilation, thermal condition, acoustic control, fire safety and aesthetics are factors that can influences health and safety in an educational buildings. These are evidence for the importance of adequate facilities and conditions in educational buildings.

SBS and Educational Buildings:

There are different ways to solve or remove problems derived by sick building syndrome but there are also different strategies and actions to prevent it. Just like all the other diseases, it is better to prevent SBS rather than trying to solve or remove it from the effected environment. The best approach to overcome SBS in a new building is for the design team to factor out the aspects associated with the cause.

Nowadays the demand for having energy efficiency is more than ever, and it has affected the Building Regulations. But there is also a crucial demand for research and consider SBS in todays' energy efficient buildings. According to number of recent studies, using energy efficient strategies to design new buildings highly neglects the negative effects of this process on SBS which arises concerns as there is not also adequate knowledge and skills at this subject (McGill, G., Oyedele, L. O. 2015).

This is contradicting with theory of designing tighten building envelopes, decrement of ventilation and using new materials and strategies which the results and possible consequences of it remains unclear with just relying on new technology to reach energy efficiency while indoor air quality is not considered.

In order to have healthy building which does not have negative impacts on users, the conditions and design strategies need to be according to function of the building; for example design criteria and standards of a residential building and office building is different.

At this chapter possible solutions for different causing factors of SBS which has been mentioned at previous chapter is discussed on educational buildings which is the limitation of the study.

4.1 Spatial and Dimensional Features

Space dimensions and conditions must be according to function of the building. Every building requires different conditions and standards in order to provide a suitable environment for the user to perform the required function without difficulty and disturbance.

In order to prevent SBS in a building the first step is to follow the standards and considerations at design stage to decrease the possibility of arising problems and disorders at later stages. Wrong or poor spatial and dimensional design decisions may lead to SBS problems such as fatigue, depression, concentration and psychological disorders which is shown at Table 1 in previous chapter.

There are different design strategies and standards for different types of classroom in an educational building. Classroom types are classified in various ways in different studies. Table 4 shows an example of classroom types classification according to classroom design standards-New York State Department of Health.

Table 4: Different classroom types and area requirements (Leigh, J. Paul, Steven B. Markowitz. 1997)

Setup Style	Space per Person	Notes
Type I Classroom: General	17 – 22 square feet	Allows for use of rectangular tables that are 6 or 8 feet long and 18 inches wide, with 2 fee per person and 3.5 feet between tables as the minimum for comfortable set. When using 30-inch tables, add 1 square foot per person to these figures. Always use the larger area per person when the speaker is on the long wall, since this set is less efficient.
Type II Classroom: 60 People or less	22 to 23 square feet	As noted above.
Type III Classroom: Practical Skills Classroom	25 Square feet	Variables must be considered dependant upon what type of skills are being taught and the amount of student participation at any one time.
Type IV Classroom: Computer and/or Distance Learning Classroom	30 to 40 square feet (dependant on use)	For use of individualized computer or laptop workstations, 30 to 40 square feet is required. For use as distance learning for generalized lectures, all requirements for types I and II must be followed.
Type V Classroom: NYS BEMS Final Practical Skills Examination Facility	100 square feet per practical skills testing station	For use of the NYS BEMS Final PSE
Type VI Classroom: NYS Written Certification Examination Facility	Approximately 31 square feet per candidate.	For use of the NYS BEMS Written Certification Examination

Some of the design considerations which are recommended for classroom design are listed below: (Carey, K. 2016).

- The form and orientation should match to teaching style and number of students.
- Classrooms must be in a 2:3 or 3:4 width to length ratio. Long or narrow rooms are not adequate.
- Flexibility of space is important. More space devoted to each person creates the flexibility possibility.
- Clear visibility in the classroom with no disturbance of columns.

4.2 Indoor Air Quality Problems

Recently the problems derived by asthma has been seen more in the industrial countries. The young generation and children spend huge amount of their time at educational buildings. It is important to prevent or solve possible SBS problems in order to provide a healthy environment for students so they can perform well and be productive (Bayer-Oglesby, L. 2005).

Analyzing quality of indoor in schools helps can help to distinguish pollution sources and apply corrective adjustments. Outdoor pollution, ventilation equipment, furnishings, and human activities all affect indoor air quality. In school classrooms the occupancy density is high (1.8 to 2.4 m2/ person) compared to offices (10 m2/ person).

Despite to design considerations and standards that has mentioned, there are also some steps to solve or remove the SBS problems caused by poor indoor air quality which are listed as below: (Hays, S. M., Gobbell, R. V., & Ganick, N. R. 1995).

Source Control: the first step towards solving IAQ problem is pointing out the possible causing factors which has been discussed in previous chapters like chemical contaminants, ventilation system, temperature and etc.

Cleaning up Dampness and Mold Signs: Mold can exaggerate disorders like allergies irritation of eyes even in people who are not allergic, the damp areas are most likely to grow mold and has to be investigated carefully to clean and remove the mold if there is any.

Increasing Ventilation: After recognizing the pollutants and removing them, the air needs to be cleaned. OSHA indicates that the best way to solve indoor air quality problems is providing a sufficient amount of fresh air using natural or mechanical ventilation. Natural air circulation inside the building should increase by opening doors or windows, turning on fans and air conditioning system.

Ensure Proper Air Filtration/Cleaning: air cleaners and air purifiers provide a healthy indoor environment and can decrees the risk of some symptoms such as asthma, dry throat and itchy skin.

Changing Old Filters: Old or ruined filters in air conditioning systems , are one of the key factors causing poor IAQ and they need to be a major cause of indoor air pollution, which needs supervision and replacement if it is needed.

Smoking and Spraying Inflammable Products Prohibition: Smoking and using different sprays which are being used in some classrooms are a major cause of pollutants and effects indoor air quality and have diverse effects on human health.

4.3. Visual or Lighting Problems

Lighting condition in educational buildings and classrooms is a very important subject. A poor lighting condition can lead to SBS problem and affect students' health and productivity whereas a good lighting can improve physical and mental health of students, create a good mood and boost immune system.

Natural Light: students spend huge portion of their day, this limits their exposure to daylight and outdoor environment which is crucial for their health. Natural light is a key factor to have effective and proper lighting condition in classroom and use

artificial light when natural light is not available. Natural light may have physical and physiological advantages to building users such as students and teachers and can increase their concentration, productivity and have a better understanding from their lectures.

According to a research by the Heschong Mahone Group (2002) providing proper natural light for classrooms can increase students' achievements at tests and exams up to 18% higher in compare to students who are at classrooms with inadequate or no natural light.

Artificial Light:

Correctly adjusted lighting system needs some consideration as listed below: (Benya, J. R. 2001).

- Illuminance
- Uniformity
- Glare
- Flicker
- Colour

lluminance alludes to the medium level of light in a region. Low luminance has been connected to slower perusing, decreased concentration, poor stance and long term vision disorders. An extreme variety of luminance can likewise be problematic.

Glare happens when an image or brightness that is unwanted perceived by student directly or by a reflection. Despite the fact that student will try to readjust by turning

their head, glare still meddles with visual tasks and may cause to SBS symptoms like eye strain , headache or lack of concentration.

Flicker is created by particular lighting material and may lead to inconvenience or disturbance. At a more genuine level, it may cause to visual disorder.

Colour is another important factor in schools, a suitable color rendering is crucial for learning quality by providing students a proper color perception condition.

According to rules and standards, classrooms lighting should be according to variety of different zones. There are different possible lighting scenarios by combining or dimming different zones. The factors that need to be considered in classroom lighting are daylight, energy efficiency and controllability.

Artificial light type should be choose wisely because it affects students' health; for classroom condition, white LED bulbs are suggested for a good lighting condition. Whereas fluorescent lighting is not suggested to be used for classrooms because it may lead to different health problems for students and staff.

4.4 Acoustic and Noise Condition

Acoustic and noise control is a key element when it comes to educational buildings and classrooms. Poor acoustic condition and unwanted noises can reduce students' concentration and learning capacity and it can lead to SBS symptoms and make an unhealthy situation for students.

Noise definition is set of unusual and physiologically unpleasant sound. It can be result of indoor origins like mechanical or ventilation system, or from outdoor sources like cars or construction sites (Çevre Orman Bakanlı˘gı 2008).

Every classroom in schools must have proper acoustic conditions and suitable insulation to prevent students from unwanted noises.

There are three main concerns regarding to acoustic and noise control: (Markham, B., Wagner. 2009)

Background Noise must be at lowest level in classrooms so teacher does not have any problem for his voice to be heard. A loud background noise may result to hearing discomforts and disorders for students.

Reverberation Time should be adjusted between 0.5 to 0.8 seconds, it should even be shorter if there is a student with hearing disorder in classroom.

Sound Isolation: the sounds that leak into classrooms from outdoor near environment can distract students. A major reason for this is the thin and light doors being used in classrooms or thin walls without proper sound insolation.

In order to solve acoustic problems in classrooms the best way is to prevent the problem rather than solving it like the other causing factors of SBS. Considering acoustics at construction stage is preferred by making adequate insolation in walls, thickness of the walls and even good decision of choosing location of the classroom to keep away from noisy places. But it is not an option for existing buildings, there are

some solutions for classrooms with problematic acoustic conditions which can reduce or solve the problem which has mentioned below: (Ising, H., & Kruppa, B. 2004).

The first step is to point out the noise origins like ventilation or air conditioning systems or any mechanical equipment and etc.

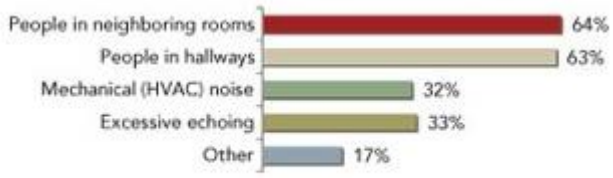


Figure 12: Acoustic dissatisfaction factors in school (Berg, F. S., Blair, J. C., & Benson, P. V. 1996)

Figure 13: Acoustic absorbers example (Gade, A. C. 2011)

- Use some techniques for isolating sound like installing tile panels to absorb noise especially if the walls are thin.
- Closing unused ducts
- Using carpets or materials which can absorb noise instead of hard floor.
- Using double glazed windows
- Placing plants and trees to block outside noises.

4.5 Psychological Issues

Psychological aspect of SBS is a factor which there are some debates about it among researchers. At some researches psychological issues have been recalled as an exaggerating factor for the other existing problems and disorders related with SBS. For example if the building is suffering from poor indoor air quality, the psychological issues exaggerate this issue for the users and symptom reports increases; however at some other researches it has been claimed that psychological issues despite exaggerating other factors, it can be also a causing factor for SBS by itself.

There are some work-related factors like high stress, excessive workload, contradiction at work and weak management system which can increase the SBS related symptoms report (Skov et al. 1989; Norbäck and Edling 1991).

Although the mentioned problems which leads to psychological disorders were about working environment, it implies for educational and teaching environments as well. Students have lots of work load, different projects and submissions that puts pressure and stress on them which can increase the effects of other existing disorders.

There are some solutions in order to reduce the possibility of psychological issues like providing a safe and calm environment with less tension and good management of the organization, but in case of educational environment the main prevention approach is to solve or remove the other factors like spatial and dimensional issue, indoor air quality, lighting condition and acoustic condition because they effect the psychology of students in various ways like anxiety, feeling stressed or lack of concentration.

4.6 Chapter Summary:

In general in order to prevent or solve SBS in educational buildings, despite to suggested approaches and ways to reduce or remove the causing factors, training students and increase their knowledge about the SBS like to not smoke and use aerosol sprays inside the building, opening or closing windows when it is needed and proper use of air conditioning system issue and its' importance is a very effective way to reduce prevalence of SBS in schools and classrooms. A proper Management and maintenance systems will help to achieve a safe and healthy environment. (Letz, G. A. (1990, May).

Chapter 5

CASE STUDY

Sick building syndrome is a major concern in all types of buildings nowadays as it effects the user in various dimensions. But it is even more important in certain cases as it directly effects the productivity and health of the users. So further studies are needed in buildings which high productivity and concentration are crucial like working environments and educational buildings.

Schools and educational buildings usually have a big number of users in compare to other facilities and buildings. Recent researches shows that educational buildings have serious indoor environmental problems, and ventilation rates are not adequate according to standards (Daisey et al. 2003).

There are relatively more researches about working environments in literature while educational buildings are as important as working environments because they are highly at risk of SBS, so this research is focused on an educational building to investigate different dimension of the issue.

5.1 Selected Cases

As mentioned before educational buildings and schools are highly at risk of being affected by SBS and problems derived by it. At this research Interior Architecture Department studios of EMU (Eastern Mediterranean University) at colored building

are selected as case studies to be investigated and analyzed to figure out if they are affected and suffering from sick building syndrome symptoms.

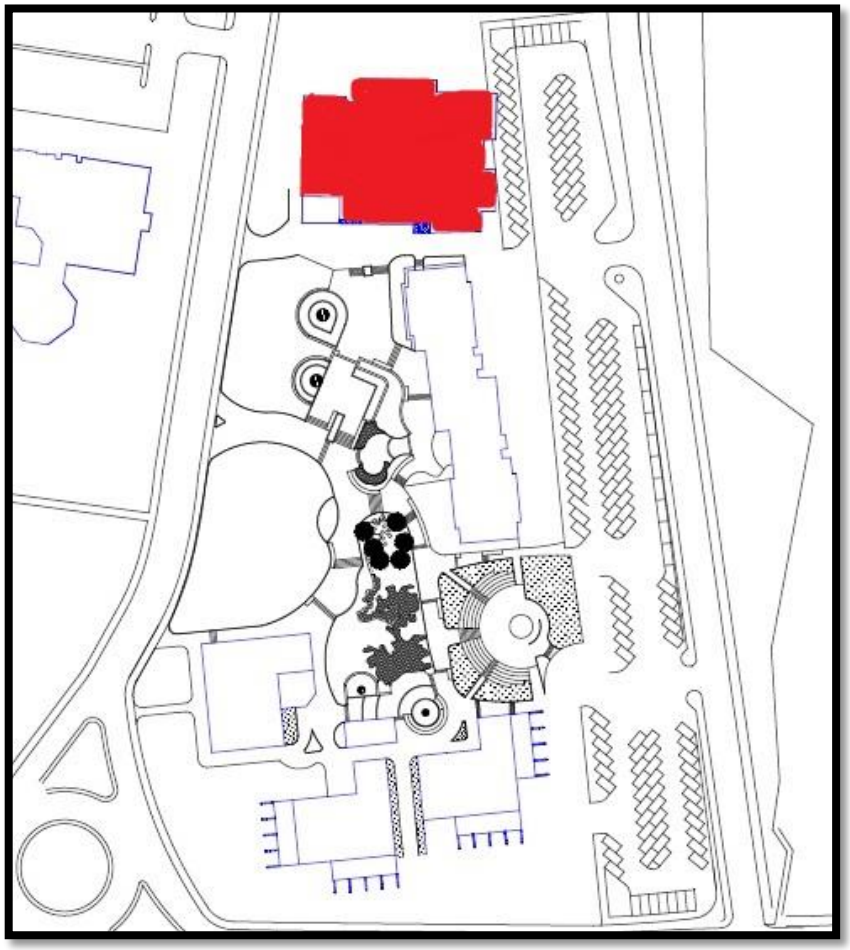


Figure 14: Position of Colored Building in site plan of Architecture Faculty

Figure 15: EMU Colored Building (Taken by Author)

The reason for choosing this building to analyze is that it is an educational building which makes it a potential victim of SBS but also the fact that they are architecture and interior architecture studios increase the need for even more attention and consideration among other departments or educational buildings because of special conditions and activities taking place at these studios in compare to normal lecture classrooms like practical courses which involves model making and usage of different materials like glues and sprays which can pollute the environment while it also require long hours of working in studios with high concentration.

Among different classrooms at Colored Building, two of the studios (A18 and A27) have been selected to be observed and look for SBS signs as they seem to be more at risk because of their condition like their location, proximity to outdoor and indoor noise and odour pollutants, long hours of usage even after the lecture hours and also recent complains of student and teachers who use these classrooms. These two studios are similar in terms of shape, dimension and location but in different floors and the reason for choosing such similar cases is that they share similar characteristics and conditions so students and users of these classrooms experience similar conditions, so collected data from each classroom can be compared to the other one, and the similarity of the outcome can be a proof for accuracy of the results.

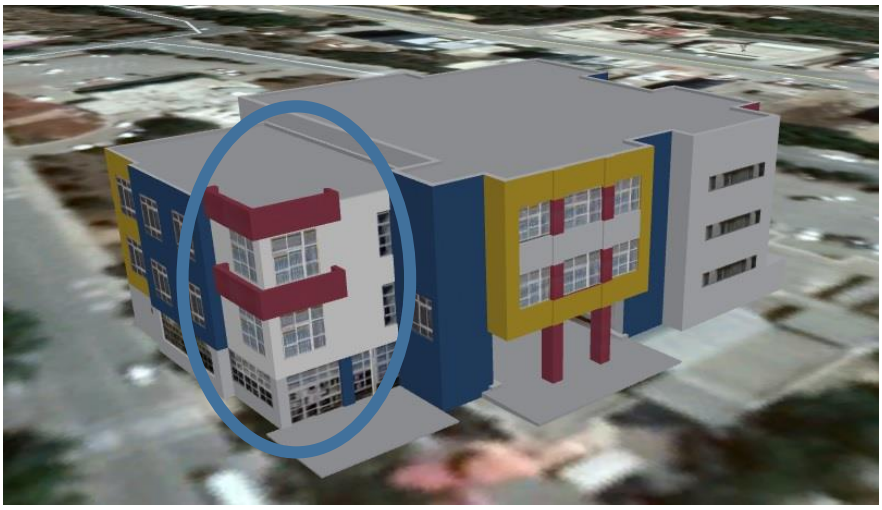


Figure 16: Exterior view of selected classrooms(Taken from Google Earth)

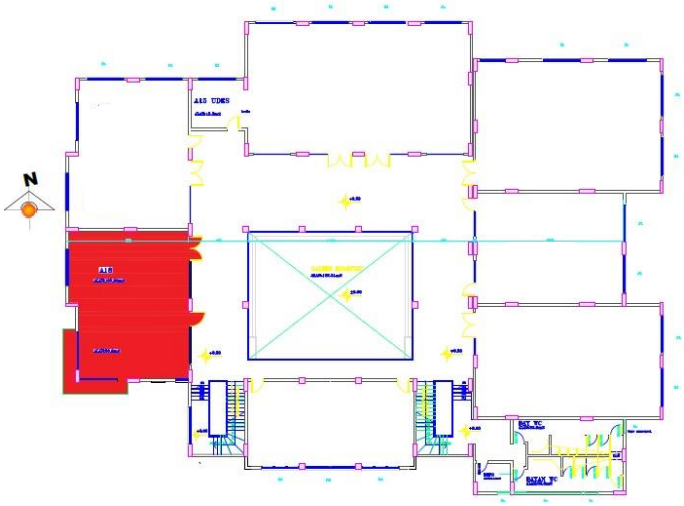


Figure 17: A18 classroom plan layout (First Floor)

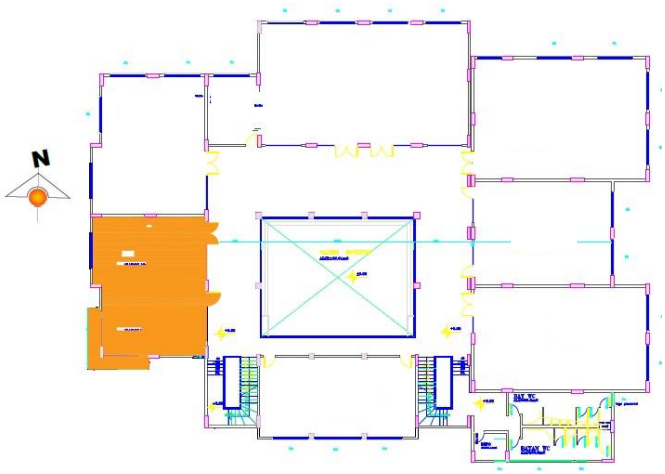


Figure 18: A27 classroom plan layout (Second Floor)

5.2 Observation

Combination of quantitative and qualitative approach is used in order to collect the needed information and data at selected case studies. As discussed in the literature and previous chapters there are a huge list of possible causes for SBS which are in a very vast range. In contrast to building related illness (BRI) which the causes for it are distinguishable and diagnosable, SBS is not easy to figure out, it needs profound and professional investigation to dig into the issue and analyze every possible causing factors at the environment using different materials and equipment to point out the problem. But there are some factors which are considered to be main factors leading to SBS which they do not need equipment or professional supervision to find them.

This chapter is limited to investigate those factors which have been mentioned as the most common factors of SBS according to literature which have been discussed in previous chapters and can be seek and analyzed by observation and relying on data collected from students who use the studios.

5.2.1 Spatial and Dimensional Features

Dimensions of a place needs to be according to function of the place. There are different regulations and standards for every function which can be found at ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers).

According to standards, the standard classroom size with practical courses is 25 square feet (2.3 square meter) per person. Average student number at each course being held at these classrooms is 30 students, so there is need for minimum 70 square meters while the area of these classrooms are 107 square meters which is adequate.

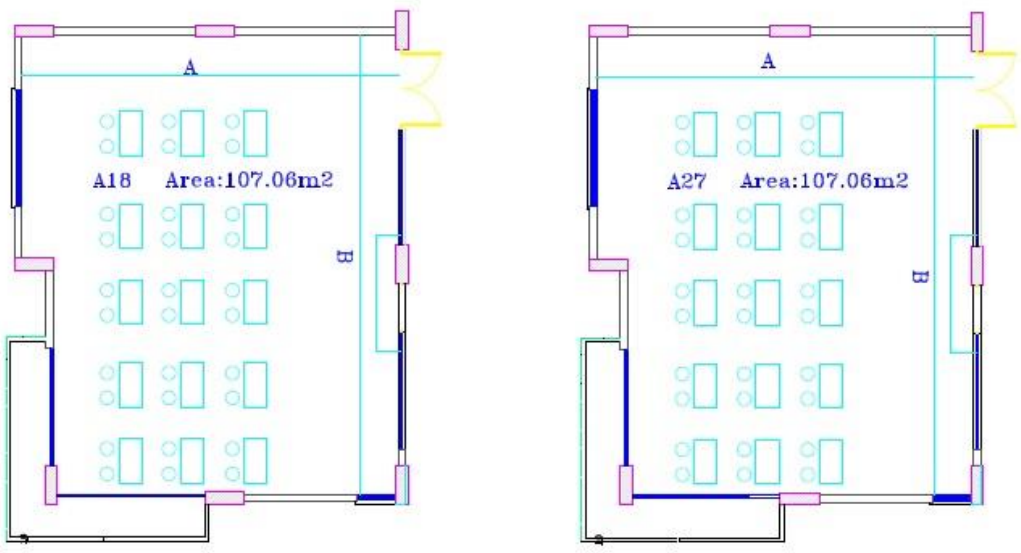


Figure 19: Area of A18 and A27

Also there is no disturbing element like columns inside the classroom to disturb the visibility of the students. The dimention ratio of the classrooms are 9.6 to 11.8 meters which makes the ratio of 3:4 which is acceptable for the classroom design according to standards but the teaching stage is at the long length of the classroom which is not adequate for a good functioning classroom.

5.2.2 Indoor Air Quality

Investigating and analyzing indoor air quality in educational buildings is hard and challenging for scientists and environmental engineers. Such investigation needs an expert team consist of mechanical engineers, air conditioning and ventilation engineers (Molhave 1986).

This research is limited to simple observations and seeking problems and signs that are mentioned in literature that may be a cause for SBS without using expert analyzes and equipment.

5.2.2.1 Air Conditioning

Air conditioning system of the selected cases (A18 and A27 studios) are old and they do not perform in an optimum level. They use a central degree system which makes trouble for users to adjust the degree according to conditions and this leads to lack of thermal comfort which is one of the main causes of SBS as a room with too high or too low temperature leads to fatigue, bad moods and productivity decrement.

Figure 20: Air conditioning of A18 Classroom (Taken by author)

Air conditioning systems require consistent maitanance and adjustments in order to perform adequatly but these systems are not easy to have a control and management on them as they are old and finding proper pieces to replace with old ones is hard. this lack of maintananse can draw pollutants into the building which is another important factor of SBS.

Excessive sunlight and the resulted by that entering from west side windows in evening can also influence indoor air comfort. As it is clear in the plan of the studios, the windows are towards west side which means excessive overheating and glare in the

afternoon which leads to lack of thermal comfort and this means possibility of causing to SBS symptoms like fatigue and lack of concentration.

5.2.2.2 Odour

Bad odours are one of the common factors of SBS, they are organic or inorganic combinations which drop in from inside the building or they can enter from an outdoor source. The odours from inside the building include furnishings, house or work furniture, inadequate ventilation and mould existence in the place. They can also enter the building from outdoor sources like by proximity to pollutants like streets or an environment which produces pollutants or smells.

A18 and A27 studios are suspected to be suffering from symptoms related to odour as it has the potential to be polluted by both indoor and outdoor pollutants. Poor ventilation and air-conditioning system is a cause for indoor contaminants like moulds which can even grow faster in buildings that face towards the west as the excessive sunlight in afternoon exaggerates the process. And also they are in close proximity to cafeteria of the building as they are located exactly at same side of the building in upper floors of it which draws the unpleasant odours and smell into the studios.

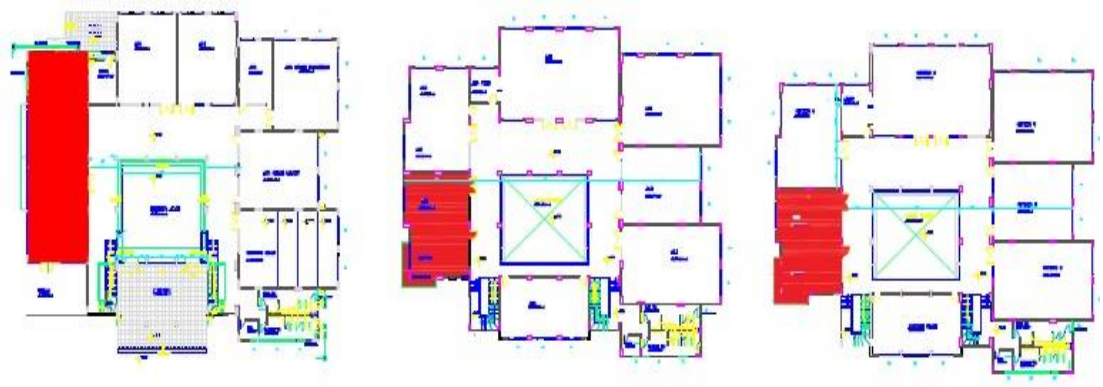


Figure 21: Proximity of selected case and cafeteria

5.2.2.3 Environmental Tobacco Smoke and Sprays Usage

Environmental tobacco smoke is another problem which exists at the selected studios. It is a critical issue at ventilated indoor environments not only for the discomfort that it makes because of odour attributes but also for the negative health effects on users of the space. The issue is not known as the main reason of the complains, but it has consistently been seen as a contributing element. Environmental tobacco smoke leads to high level of VOCs, toxic combinations, and recoupable particulate matter. Reflow of the air which is polluted with ETS, if no purification or air-washing, applied can lead to symptoms such as headaches, eye irritation, dizziness and lack of concentration.

Although the studios and building have smoking restriction but is not being followed by some students, especially after the lecture hours when studios being used by students for making projects and there is no any control.

Figure 22: Smoking prohibition sign at building (Taken by author)

Glues, sprays and aerosols are named Volatile Substance Abuse (VSA) or Volatile Substance Misuse (VSM) in some researches. They are made of volatile materials that

are depressants, they slow down body and brain, and cause to mood changes, dizziness, red rashes on the face and intense headache.

Both case studies (A18 and A27) have design lectures taking place in them which students use different glues and sprays and color sprays to make their projects, this process goes on even after lecture hours during the nights by students which contributes to high level of dangerous contaminants in the space.

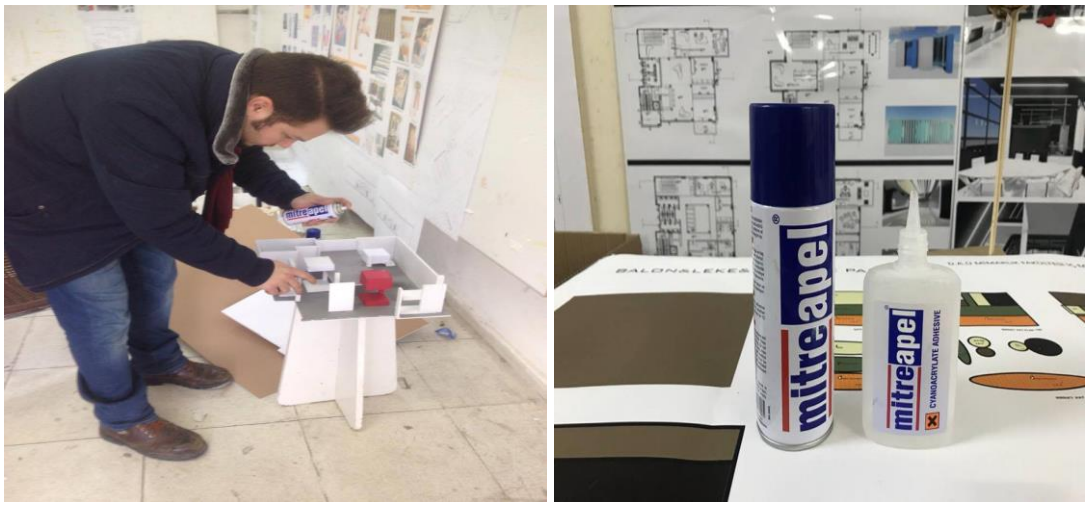


Figure 23: Example of spray being used at classrooms (Taken by author)

5.2.3 Lighting Quality

according to the Thurston County, Washington Department of Public Health and Social Services, a fluorescent light bulb lasts up to ten times longer than other types of lighting, and uses a mere one-fourth of the energy burned by incandescent bulbs. This economic and environmentally conscious form of lighting can lead to both positive and negative health effects.

Studios in colored building of EMU including selected case studies (A18 and A27) use fluorescent lighting like most of the buildings as it is the most common choice nowadays.

Figure 24: Fluorescent lighting of A18 classroom (Taken by author)

Fluorescents produce light when an electric current excites mercury vapor inside the glass tube. That vapor produces a short-wave ultraviolet light that causes the phosphor coating that lines the inside of the tube to glow.

Both classroom get natural light as well. The windows are facing towards south-west and west side as it is shown at figure 25 Which is not proper daylight condition for a classroom; west side windows attract excessive sunlight to the classroom which is disturbing both visually and from thermal comfort point of view. Figure 26 and 27 show the sunlight condition of the classrooms at different times of the day.

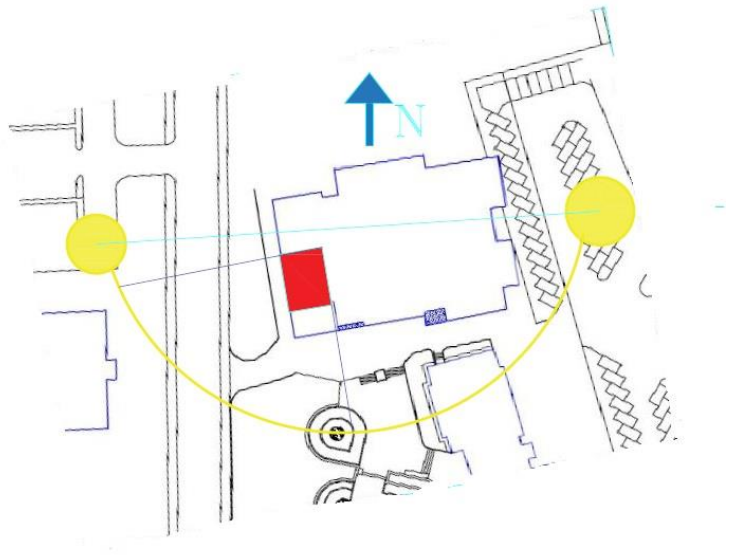


Figure 25: Sun direction path for selected cases (Made by author)

Figure 26: Daylight condition of classrooms at 11 am (Made by author)

Figure 27: Daylight condition of classrooms at 2 pm (Made by author)

5.2.4 Acoustic and Noise Comfort

Poor acoustic condition in schools may lead to different health problems. Researches show that poor noise condition may result to symptoms like high blood pressure, headaches and fatigue.

A18 and A27 studios are polluted with both indoor and outdoor noise pollutants. Air conditioning systems produce a relatively loud background noise as they are old and it makes problem for teachers and students.

Also these two studios have windows that is facing towards cafeteria and street which produces distracting noises during studio hours which can affect students negatively and cause to lack of concentration, fatigue or headache.

Figure 28: Exterior view of A18 classroom and cafeteria closeness (Taken by author)

5.2.5 Psychological Factors

One of the main reasons for absence of a precise cure for sick building syndrome is that most of the attention and researches are focused on physical and environmental

aspect of the problem. If the issue was only about physical aspects, there could be a cure or solution to eliminate the issue, so it is possible to indicate that SBS is not entirely a physical problem.

Another important dimension about SBS subject is psychological factors which is a major problem in educational buildings. There are different factors which may cause to psychological problems that leads to SBS like work load, job satisfaction, lack of control, work or school related stress and job satisfactions (Gomzi et al., 2007, Hansen et al., 2008).

These factors can affect the users in different ways, they can affect the users' concentration and productivity but more importantly psychological factors can exaggerate the existing physical problems like indoor air quality or other problems in the environment, so it is crucial for user to work or study in an environment that they are psychologically satisfied.

This issue is also a major concern in educational buildings. But it is even more important in selected case studies (A18 and A27) because of some special conditions that these studios have. Architecture or Interior architecture are majors that puts excessive work load and stress to students like different project deadlines and juries which takes place at the studios. This stress and workload makes a space memory on the students which makes them feel the pressure and stress while they are at these studios, the juries and practical exams usually takes place at the these studios which students already spend long hours during the week in studio hours and there is a background and reminder of the jury and exams stress and panic for them. These

feelings effects the students psychologically and gives them a stressful and unpleasant psychological perception which can reduce their productivity at these environments.

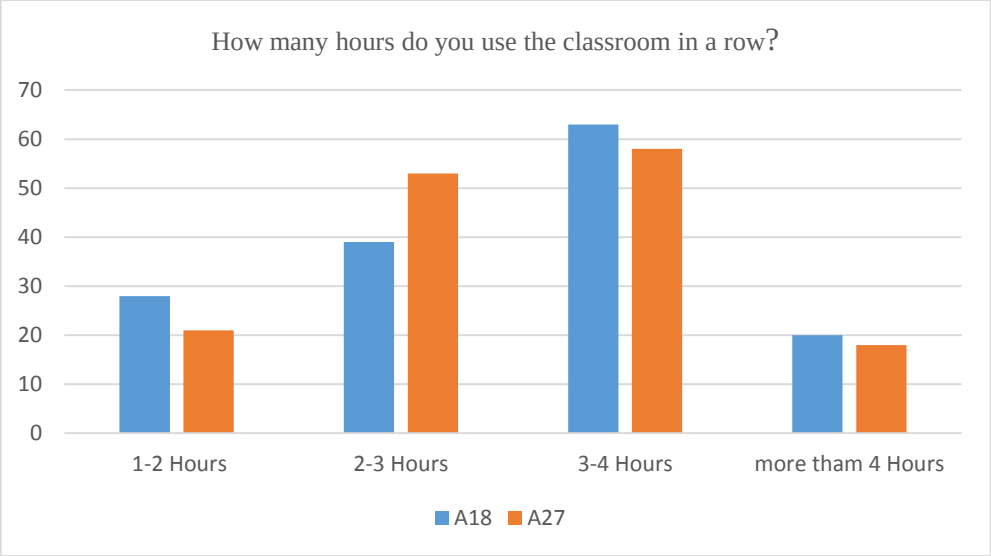
Figure 29: Jury being held at A27 classroom (Taken by author)

5.3 Data Collection

According to information obtained from literature about SBS, observations and investigations made on A18 and A27, these classrooms might be suffering from SBS as they have some factors which are a cause for existing of SBS.

150 questionnaires distributed among students and teachers in each classroom (total 300) including questions about possible signs of SBS and their experience at these studios to find out if they are suffering from any disorders which may be linked to SBS symptoms. Sample of questionnaire is shown at Appendix A.

Table 5: Duration of classroom usage by students



In order to get a more reliable results, the data must be collected from users who use the building for a relatively long time in a row like more than two hours to make sure if there is a disorder that can be related to the time spent at the building. Table 5 shows that more than 70% of the students at both studios spend more than two hours in a row in the studios.

Table 6: Complain reports from A18 studio

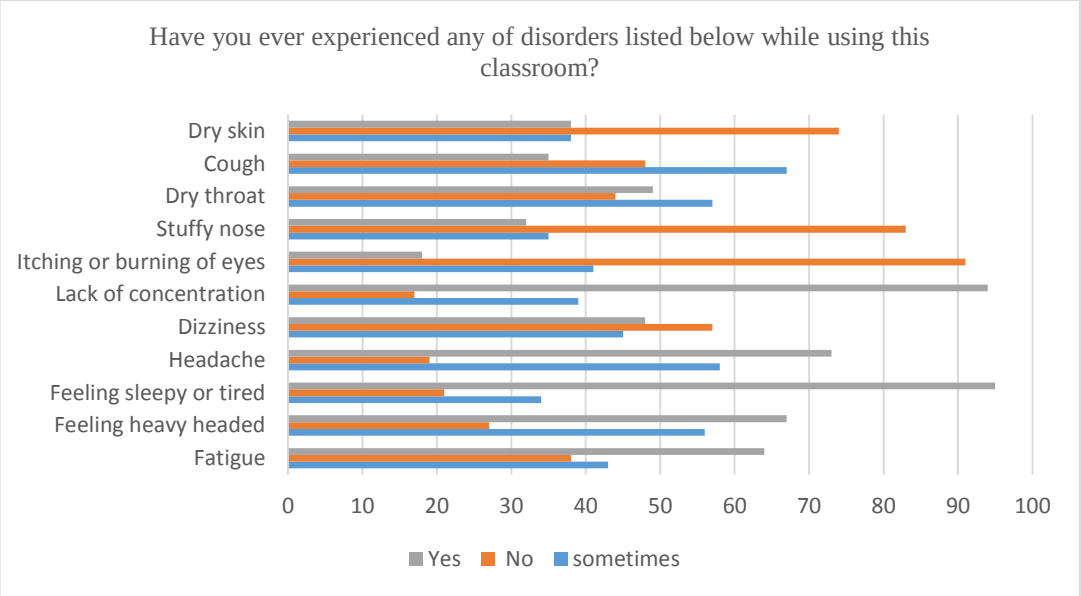
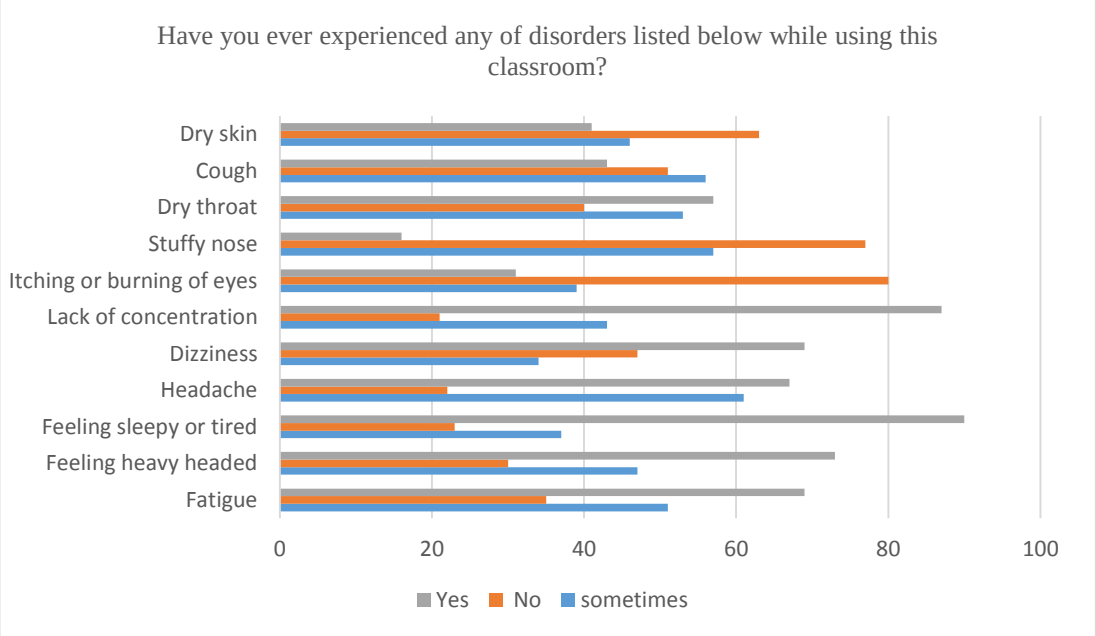


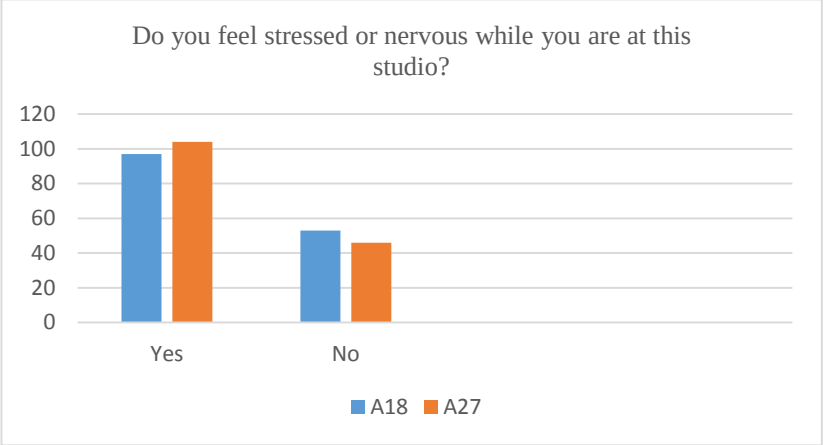
Table 7: Complains report from A27 studio



As mentioned before there are a long list of SBS symptoms and different classifications for them in different researches. Some of the main symptoms has been collected from literature and have been asked from students of both studios to find out if they are suffering from these disorders.

The gray line in the chart shows the answers which refers to existing of the mentioned symptoms, as it is clear the gray line is longer in most of the listed disorders in both studios which is a proof for existing of problem in studio condition and they are suspected to be called as ‘sick’ building. Another important information which can be concluded from these charts is that the most reported symptoms in both studios is about feeling sleepy or tired and lack of concentration which is a big problem at this case as it is crucial for students to be concentrated and productive.

Table 8: Stress level report from A18 and A27 students



Despite the existence of symptoms reported at Table 6 and 7 which were mostly physical, the psychological factors must be taking into account too because they can cause or exaggerate the existing symptoms, and as mentioned before there are some factors at these studios in compare to other classrooms or departments that can lead to panic and stress like juries and project deadline which turns into a memory of space in students background. Table 8 shows that most of the students in both studios feel the pressure and stress while they are using the studios.

Table 9: Location of symptoms occurrence

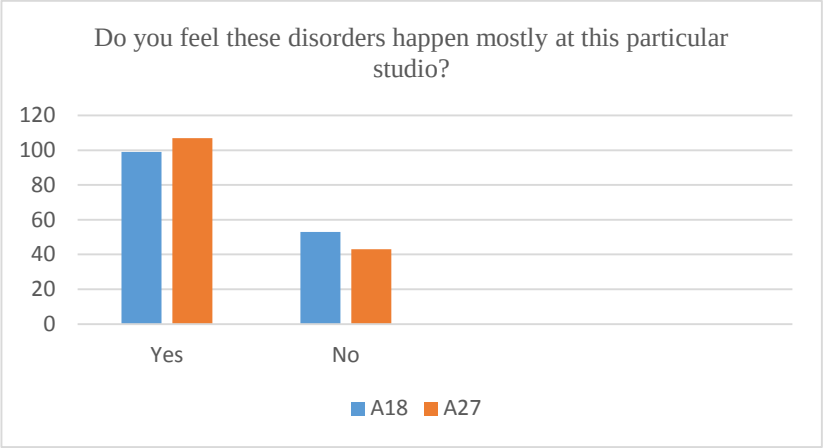
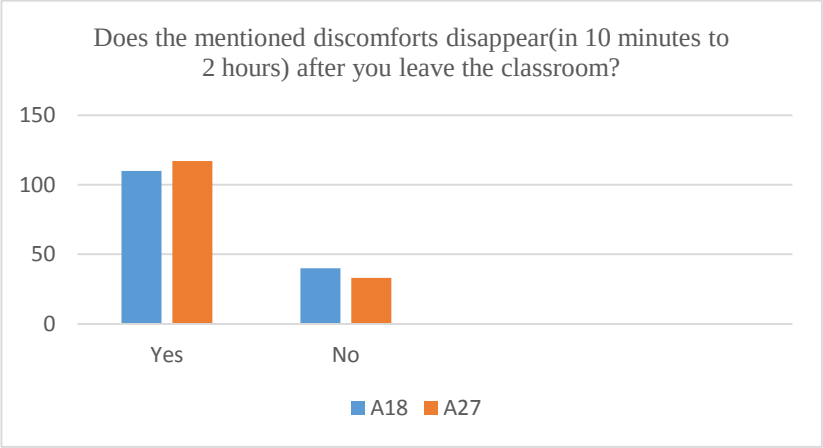


Table 10: Symptoms relief condition at A18 and A27 classrooms



Existing of the symptoms is not enough to figure out if the building is sick, there are more conditions required like if the users feel these symptoms at the particular selected environment or not which table 9 shows that around 67% of the students claimed that they feel these conditions at this studio.

Also more importantly, the experienced symptoms must disappear when user leaves the environment after a while and table 10 shows that around 80% of students in both studio claimed that they do not feel the disorders after they leave the studio for between 10 minutes to two hours.

According to definitions and information obtained from previous chapters. And investigations and analysis on studios conditions, the collected data from two studios which are quite similar to each other can conclude that these studios are suffering from SBS symptoms.

Trying to remove and solve these symptoms generally need expert professionals and in some case might need lots of time and cost, but just like the possible simple investigations, some simple solutions might be applied as well like maintaining and refreshing indoor air quality by checking the air conditioning systems, changing lighting condition by reconsidering the lamps type being used, giving adequate and complete information to students about how smoking or using different sprays in the studio can harm their health and productivity and apply some noise and acoustic protectors at these studios. And for psychological aspects there might be need for further studies and researches to figure out how this condition can be improved because it is probably the most important factor among the others as it exaggerate the other existing problems.

5.4 Results and Suggestions

According to information obtained from literature and applying those on observations, the selected case studies seemed to have signs of SBS. Although the spatial and dimensional condition of the classrooms were acceptable, indoor air quality, visual and lighting, acoustic and psychological condition of the classrooms seemed problematic according to observations and investigations. Along with these information, the data collected from questionnaires which converted to charts showed that there are large number of complains among the students who use these classroom.

The ‘American Standards for Heating, Refrigeration and Air-Conditioning Engineers ’ (ASHRAE) claims that when 20 percent or more of its users report or complain of disturbance symptoms for more than two weeks and infected users relieve from reported symptoms shortly after they are away from the building the building can be called as sick ’ (Jansz, J. 2011).

Almost all of the symptoms were reported more than 20% by the students in both classrooms according to table 6 and 7; also 67% claimed that they experience the disorders at the particular selected classrooms and 80% mentioned that the symptoms disappear after a while that they leave the building which are key factors to relate the disorders to existing of SBS.

Table 11 includes the complaint reports by percentages in both classrooms, the orange column indicates the answer ‘yes’ and yellow column is for answer ‘No’, according to numbers the results for symptoms are very similar at the two classrooms which makes the obtained data and result more reliable.

Table 11: Comparison of symptoms complain at A18 and A27 classrooms

List of Symptoms	A18			A27		
	Yes	No	Sometimes	Yes	No	Sometimes
Dry skin	26%	49%	25%	27%	42%	31%
Cough	23%	32%	45%	28%	34%	38%
Dry throat	33%	29%	38%	38%	26%	36%
Stuffy nose	21%	54%	25%	20%	46%	34%
Itching or burning of eyes	12%	60%	28%	19%	52%	29%
Lack of concentration	62%	11%	27%	58%	14%	28%
Dizziness	32%	38%	30%	42%	31%	47%
Headache	48%	13%	39%	45%	15%	40%
Feeling sleepy or tired	68%	14%	18%	61%	15%	24%
Feeling heavy headed	44%	18%	38%	48%	20%	32%
Fatigue	42%	25%	33%	45%	23%	32%

Suggestions:

According to definitions of SBS, with relying on the obtained data the selected classrooms can be called as 'Sick Building' and student are suffering from the problems derived by it. As mentioned at chapter four, there are some ways to reduce or solve the issue by some actions.

Spatial and Dimensions: The classrooms provide the standard area requirement per person, but the formation of the classroom is problematic, this issue can be solved with small adjustments like changing the direction of furniture and teaching stage. The class formation has been shown at figure 19, if the students' seats direction change towards side A which is the shorter length, it can help to reduce SBS symptoms like lack of concentration.

Indoor Air Quality: it can be suggested to change the air conditioning system if it is possible as they are old, and if it is not possible they have to be checked by experts, the filter must be changed and a proper maintenance should be applied on them with

supervision of the experts. Also smoking and spray usage prohibition needs to be taken more serious and students should be given enough knowledge and information about how these problems can lead to SBS and affect their health.

Visual and Lighting :For improving natural light condition of classrooms in order to control the excessive sunlight entering to the classrooms from west side, providing a vertical shading device could reduce this problem. The artificial lighting system also needs reconsideration. The fluorescent lighting system in the classrooms are not providing adequate visual comfort for the students. The negative effects of this lighting system has been explained at previous chapters; using LED lights can be the solution for this problem as it is suggested as the best case for educational buildings.

Also a zoning lighting strategy could help to increase the lighting condition; the lights should be zoned according to student seats and teaching stage.

Acoustic and Noise comfort: as mentioned before the classrooms suffer from both indoor and outdoor pollutants; for indoor sources, checking and repairing air conditioning systems, and applying sound absorbing panels or tiles is another solution might reduce the problem. Also for outdoor sources providing noise insolation panel on the exterior walls can be suggested.

Psychological issues: At these cases, the best approach is to solve the other existing physical problems in the environment because psychological issues are highly influenced by these problems. Also providing a friendlier and low stress atmosphere in the classrooms and make them feel involved can have huge impact on relief of the symptoms.

Architecture Role in SBS Issue:

Generally there are different approaches to prevent or solve SBS in all types of buildings which is related to different fields like Electrical engineering, Mechanical engineering and Interior Architects.

But as mentioned before, it is better to have serious considerations and analyzes before building usage in order to avoid SBS. Architecture therefore plays an important role at this issue as most of the design decisions and considerations are being made by them.

Architects should be aware of the importance of SBS, have enough knowledge and information about the subject and apply these information on their design strategies and considerations, so the possibility for creation of conditions and problems which can lead to SBS can be decreased.

Chapter 6

CONCLUSION

Although sick building syndrome is a recent phenomenon, it has attracted attention and concern of researchers working in architecture, building construction and related disciplines. There is no doubt that the importance of the issue is increasing more and more due to the competitive world we are living in now where time and productivity is crucial and even slight problem or disorder at these cases besides to its' health issues can lead to economical damage.

It has been proved that even though health problems derived by SBS are not serious, it may lead to creation of problematic conditions and consequences. In addition to distressing effects of it on people, SBS also leads to a huge decrement of productivity, increment of absence coming from sickness and loss of precious time spent for recognizing problem and trying to solve it, even excessive cases can cause to closure or destruction of building.

Despite the importance of the issue there is not enough information and knowledge among people towards this subject, therefore this study tried to focus on this problem, study and analyze the issue from different aspects and give a more clear sight about the subject, especially on effects of SBS in educational buildings which is a major concern at such case but there is not enough research in literature about it.

In order to achieve this, the study started with brief information about history, theoretical aspects of the subject, introducing different classifications and definitions in different studies and its' negative effects on health and economy. Afterwards in chapter three different factors and causes which leads to SBS has been studied and explained and at the end of the chapter the solutions and strategies in order to prevent the issue has been explained. And finally at chapter five after getting to know the subject and different dimensions about it, these information were applied on selected case studies which are two studios (A18 and A27) used by the Interior Architecture Department studio and lecturing purposes at the colored building of the Faculty of Architecture of EMU to investigate and observe signs of SBS. According to the results of collected data it can be said that these studios are suffering from SBS disorders and some simple solutions have been suggested in order to fix these problems.

Finally after all the studies and analyses about SBS, this study will be concluded with a question and a conflict in literature which arise while doing this research. As mentioned in chapter three one of the main reasons for SBS is relying too much on another issue designers are dealing with which is sustainability. Sustainability is also an extremely important issue which is needed in order to save energy and costs at this natural resources crises, but design strategies being used in this process sometimes leads to sick building syndrome like designing tight structure buildings with less openings in order to loose less energy, but this also causes ventilation problem which is a major factor in SBS. So the study will be concluded with a statement of Dr. Joseph Allen, Assistant Professor of Exposure Assessment Science at the Harvard T.H. Chan School of Public Health :

The health and productivity benefits far outweigh energy costs and environmental impacts can be mitigated through a variety of readily available strategies. It is time we move away from ventilation designed for merely acceptable indoor air quality and move towards design for optimal indoor air quality. We have been presented with the false choice of energy efficiency or healthy indoor environments for too long. We can – and must – have both.

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APPENDICES

Appendix A: Questionnaire Sample

1. What is your gender?

Male ***Female*** ***Other***

2. Do you have any medical history about allergies?

Yes **No**

If yes, please explain:

3. How many hours do you usually use the classroom in a row?

1-2 Hours ***2-3 Hours*** ***3-4 Hours*** ***more than 4 hours***

4. Have you ever experienced any of the disorders listed as below while using this classroom?

Disorders	***YES***	***NO***	***Sometimes***
• Fatigue			
• Feeling heavy- headed			
• Feeling sleepy or tired			
• Headache			
• Dizziness			
• Difficulties in concentration			
• Itching, burning or irritation of eyes			
• Irritated ,stuffy or runny nose			
• Dry throat			
• Cough			
• Dry skin			

5. Do you feel that these disorders happens mostly at this particular classroom?

Yes No

6. Does the listed discomforts disappear (in 5 minutes to 2 hours) after you leave the classroom?

Yes No

7. Do you have much workload and deadlines at your courses being held at this class?

Yes No

8. Do you feel stressed or nervous when you are this classroom?

Yes No

9. Which courses do you get at this classroom?

Appendix B: Ethics Commitee permission

Doğu Akdeniz Üniversitesi
"Uluslararası Kariyer İçin"

Eastern Mediterranean University
"For Your International Career"

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Etik Kurulu / *Ethics Committee*

Reference No: ETK00-2017-0264 18.12.2017
Subject: Application for Ethics.

RE: Soheil Soleymani (15500125)
Department of Architecture

To Whom It May Concern,

As part of the 2017-2018 Fall Semester, pertaining to Master Thesis questionnaires EMU's Scientific Research and Publication Ethics Committee has granted Mr. Soheil Soleymani (15500125), from the Department of Architecture Master Program, to pursue with his survey entitled ***Analyzing Sick Building Syndrome in Architecture Studios of EMU***. This decision has been taken by the majority of votes. (Meeting number 2017/50-15)

Regards,

EASTERN MEDITERRANEAN UNIVERSITY ★ ETHICS COMMITTEE ★ 1979 ETİK KURULU Gazimağusa, North Cyprus

Assoc. Prof. Dr. Şükrü Tüzmen
Director of Ethics Commitee

ŞT/sky.

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