DAMPNESS IN RESIDENTIAL BUILDING IN NIGERIA: A CRITICAL ASSESSMENT OF SUB – URBAN AREAS.

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Abstract

Severe dampness in residential buildings in sub-urban areas has become a major problem to many owners and users alike. This scenario leads to deterioration in building to the extent that it ultimately undermines the structural elements. Soil profile, Silt content and pH value in conjunction with Site survey and Questionnaire were used to evaluate the causes and effects of dampness in Bosso and Kpakungu areas of Chanchaga local government area in Niger State of Nigeria. Sandy-clay soil type was dominant in the area with impervious base ranges from 4 to 9 meters deep, the silt content of sharp and plaster sands used for construction in the area were 6.8% and 10.2% respectively while the $_pH$ *values for well water is 6.8 and 7.1 for stream water with traces of* $CaSo_4$ *and* $CaCl_2$*. Total disregard to standards and methods in construction processes as well as lack of proper maintenance are the major causes of dampness. It is recommended that through proper education and engagement of qualified professionals, wet free residential buildings can be achieved.*

Key words: Building, Capillary Action, Building Standards, Rising damp, Soil Profile.

Introduction

Dampness in building becomes a problem if the moisture penetrates vulnerable materials or finishes, particularly in the occupied parts. Dampness and leaks caused by capillary action are perhaps the most problematic to treat, both for the difficulty to detect the origin of the leak and how to correct it. Dampness originates in many ways and has wide ranges of symptoms that require the expertise of the professional in the built environment to unravel. The building materials tend to attracts water molecules through its spore (capillary action) that causes rising damp through the walls and floors of houses unless preventive measures are taking to breach the difference in moisture gradient. This moisture will dissolve soluble salts from the building materials such as calcium sulphate ($CaSO_4$), and may also carry soluble salts from its source. If the moisture evaporates through a permeable surface, these salts will be left behind and form deposits on or within the evaporative surface (Seeley, 1987; Hutton, 1998; Anonymous, 2010).

Ikpo (2006) and Lekjep, Mangden and Edet (2006) state that buildings constructed without moisture barriers, inadequate roof eave and improper application of components are susceptible to dampness particularly if the water table is high and the effects of rain water. These can result to a serious health hazard and also aid the decay of skirting boards, raised ground floor members and affect paintwork, all these affects the building standards as well as undermines the structural integrity of building elements, limits the comfort of the occupants, and the attendance increase in maintenance cost of the structure (Mbachu, 1996; Oliver,1986).

It is the aforementioned problems that necessitate the study of the causes and effects of dampness in sub-urban areas where the symptoms are becoming worrisome within the neighborhood of the urban poor. Buildings are constructed with alter standards without the input or supervision of qualify professionals on a problematic soil usually swamp, in believe of saving money and desperation to leave in the city.

Therefore, this study is aimed at identifying the causes and effects of dampness in residential buildings in sub-urban area so as to proffer suggestions and methods for achieving comfortable and damp free buildings. In view of the above, the following specific objectives will be pursued;

- To determine the causes and effects of dampness in the residential building within the area.
- To determine the level of dampness in the residential building within the area.

- To examine the construction methods adopted in the area in relation to building standards in order to create the necessary awareness among the neighborhood.

Methodology

To achieve the aim of this study via the research objectives, both the primary and secondary sources of data were sourced;

Primarily, fieldworks for detailed study of construction techniques and materials adopted in building construction within the area of study were carried out, as it comply with standard building construction methods and codes as well as determining the level of dampness in the residential building within the area. The depth of ground water table as revealed by wells samples within the premises of the affected buildings and the geophysical investigation for geoelectric section or soil profiles in the study area were examined. Samples of materials used for building construction (water and sand) in the locality was collected and tested for in the laboratory. Oral interviews and Questionnaires were carried out and administered concurrently at random to same or different person within the stakeholders in the community in other to assess their opinions, impressions and experiences regarding the causes and effects of dampness in their neighborhood.

Secondarily, geophysical information for soil profiles of the areas was collected from deep well drilling company (ADEX NIG. LTD), also information from internets, extract from journals and relevant textbooks, seminar and conference papers forms the bulk of the materials used.

Background Of Study Area

Kpakungu and Bosso are towns in sub-urban areas of Chanchaga Local Government and Bosso Local Government Areas of Niger state Minna, Nigeria respectively (see Figure 1). The state lies on latitude 3.20^0 East and longitude 11.30^0 North. Kaduna State and FCT are her borders to the North-East and South-East respectively; Zamfara State borders the North, Kebbi State in the West, Kogi State in the South and Kwara State in the South West and The Republic of Benin along Agwara Local Government Area boarders her North West. The soil types as in other parts of the state are Ku soil and Ya soil. Ku soil is susceptible to little erosion, while the Ya soil has better water holding capacity.

The temperature is not different from that obtained in Minna with average temperature range between 21°C and 42°C with the annual relative humidity mean of between 50 – 55%. Niger State experiences distinct dry and wet seasons with annual rain fall varying from 1,100mm in the northern part to 1,600mm in the southern parts. The rainy seasons last for about 150 days in the northern to about 120 days in the southern parts of the state.

The Inhabitants of Kpakungu and Bosso comprises mostly of civil servant; students, farmers, business people and self employed. The house types are mostly of modern1, 2, and 3 bed room's bungalow and the traditional rectangular plans with courtyards arranged in compound form. The wall materials are made mostly of conventional sandcrete blocks with galvanized zinc as roofing sheets.

Basic Properties Of Water And Sand

Laboratory quantitative analysis was carried out on sharp and plaster sands, as well as, well and stream waters to test for properties that have effect on damp movements and chemical reactions, according to British Standards (B.S).

Silt content in Sands, and $_PH$ values and soluble salt in Water (well and stream) which are the two basic materials that can influence the damp movement within the building structure were carried out. The silt content of sharp and plaster sands used for construction in the area were 5.8% and 8.5% respectively as presented in Table 1. While the $_PH$ values for well water is 6.8 and 7.1 for stream water with traces of Calcium Sulphate ($CaSo_4$) and Calcium Chloride ($CaCl_2$).

Result and Discussion

From the result of preliminary investigation carried out on the study area, the roof structures adopted were found to be mostly conventional hip roof systems with eave extensions of 500mm to 600mm.

The buildings are mostly bungalows with few two to three storey structures. The level of exposure of the external walls of most buildings in the locality to direct sun rays and heat is low, while that of rainwater is found to be high. It was also observed that the level of maintenance in the area is abysmally low. The problem of roof leakages due to improper roof design and choice of materials has also contributed to causes of dampness of building within the settlements.

Analysis of Construction Techniques and Methods within the Area.

A thorough investigation and analysis of method and techniques of construction adopted in the area reveals that in most cases fewer people adopted the standard damp proof course (DPC) and damp proof membrane (DPM); instead cement/sand mix in ratio 1:6 is used for floors. It was also found that the hardcore thickness of 150mm adopted in most of the buildings as against the required 300m is inadequate (especially where ground water levels were close to the ground surface). In areas where the ground water level is deep down and of stepper terrain, dampness is not visibly seen in buildings at such locations, whereas where the water level is high up, dampness is prevalent in most buildings found in the locality.

Analysis of Interview and Questionnaire Administered.

A total of 126 questionnaires were administered to residents and 46 stakeholders were interviewed at random in the case study areas to reveal basically the following; Interest or Tenancy holdings that exist on the building, Age of the properties, Dampness experienced in the house, Areas of dampness experienced, Causes and effects of dampness, And the expected remedies.

About 77% of the respondents experienced dampness on various components in their buildings at various level of severity; floor, walls, ceiling, and fascia board with 73%, 60%, 84% and 49% respectively, While 37% experienced dampness in the entire components of building as indicated by the researcher. Reasons indicated for occurrence of dampness were; Negligence of landlord to regular maintenance with 65%, negligence of tenants to maintenance with 53%, vagary of weather (rain, rising water table etc) with 30%, while 44% accounted for non-application of rightful construction methods and materials.

It can safely be concluded therefore that dampness was inevitable when maintenance was relegated to the background. Hence regular maintenance and use of rightful construction methods will go a long way to reduce, if not out-rightly avert dampness in buildings.

Report on Geophysical Investigation in the Area.

Eight pre-drilling geophysical investigation reports on ground water development from 'ADEX NIG. LTD', four each for Bosso and Kpakungu areas and physical investigation of some selected wells in the areas were used to collect data on the soil profile of the areas under consideration.

An average of 1 meter top soil was reported followed by 4-9 meters weathered basement that is hard enough at the basement to hinder free percolation of water that results to early saturation and flooding during raining season. This might be the cause of the high level of dampness (78%) in the foundation of buildings in area under consideration.

Test of Efflorescence of Sandcrete Block in the Area.

Three Samples of blocks were selected randomly from six (6) different block production sites, three each for well and stream water. Tests of efflorescence were carried out on the samples and the average result is as shown in the Table 2. The average area of surface covered with these deposits of salts found in blocks used in constructing walls in the locality is 22.3%. The efflorescence developed on block walling in the area could therefore be classified as "mild". Most of the walling units in the area are therefore liable to efflorescence which could be a factor for the prevailing dampness.

Summary Of Findings From The Research Work

The main trust of this research work has primarily been on establishing the problems of dampness in residential buildings in case study areas.

The following were deduced as experiences of dampness among the residents and professionals;

- About 75% of the residents experiences rising dampness at the foundation level and other forms of dampness at varying level in other areas like; Walls, Fascia boards, Ceilings, and faulty pipes.
- Dampness is prevalent within the wet or rainy season of particular note in this case in the problem of applying appropriate construction techniques as well as use of right type building materials when erecting residential buildings in the area.
- Sands found in the area contain high silt content; this affects the workability of its products. The amount of water required hydrating the cement and sand mix for construction affects its final strength, as excess water evaporates and leaves capillary pores that reduce the strength and increases the permeability.
- The shallow impervious base in the area account for early submerges of the soil during the raining session.

This accounts for dampness experienced in the above mentioned areas of the buildings. It results in:

a. Penetrating dampness through the floor, wall and roof structures from external source of dampness such as rain water on surface of walls, ground affecting floor and so on. (see Figure 1, 2 and 3)
b. Internally, defects from plumbing works as a result of break down from sanitary wares could release water no matter how small this is left unchecked over a long period of time.
c. Efflorescence experienced on surfaces of walling units as a result of the presence of soluble salt deposits arising from the use of hard water obtained in wells in Kpakungu and Bosso used for production of blocks as well as construction of buildings.

Conclusion

Based on the findings above, it can be concluded that the causes of dampness is multi- faceted but soil characteristics and lack of adherence to building construction standards played a major role. All stakeholders complained about the effects of this menace and desired a permanent solution to the problems associated with it in the community, however, lack of resources to adhere to building standards, lack of technical know how on the part of the operatives, lack of improper implementation of building codes and regulations by the local authority, and lack of maintenance culture are the main hindrance to their dream of wet free living space.

Recommendations

Every building is constructed to provide a comfortable, safe and serene habitation for its occupants. Intruding elements, natural or manmade, should be properly taken care of to avoid the consequence associated with poor living environments. In this case the following recommendations are hereby made:

- The construction site must be properly investigated for adequate design against dampness before the construction is carried out to avoid their occurrence when work has been finished.
- Use of appropriate and proper techniques in the construction process cannot be overemphasized. For example, where the ground water level is high as noticed in most

parts of the study areas, the application of damp proof membrane and the inclusion of damp – proof course to check the permeation of water through capillary action in the Foundation level and the walls should be carefully observed.

- The water available in study areas used constructions purpose should be treated to check the level of hardness created by the presence of salts. The method used in treating portable water should be utilized. In this way, the mortar for wall construction and rendering as well as the mix for block production will be devoid of such salts.
- The pitch of roof structures should be steep enough to allow free flow of all rainwater.
- The eave projections in buildings in the study areas should be adequately provided, not less than 600mm deep. This will ensure that the upper parts of the walls are dry to avoid down ward transmission of water to affect the lower parts of the buildings.
- The mortar mix used for rendering as well as for construction in the study areas should be rich (1:3) in cement content to avoid easy peeling off.

TABLE 1 – Test for Silt in Sand Use for Block Production and Wall Rendering in Kpakungu and Bosso Areas.

	SAND			PLASTER		
SAND						
SAMPLE	1	2	3	1	2	3
Silt thickness (mm)	5.7	6.4	9.6	10.0	10.0	10.2
Sand depth (mm)	98	96	102	95	103	98
Silt contents (%)	5.8	6.7	9.4	10.5	9.7	10.4
Average silt contents (%)		6.8%				10.2%

Source: Author's field report, 2011.

TABLE 2 – Test of Efflorescence of Sandcrete Block

SAMPLE	Well	Stream
Area of block faces (m^2)	0.30	0.30
Area of block covered with salt deposit (m^2)	0.36	0.98
Percentage (%) area of face covered with salt deposit	12.1	32.5
Average percentage (%) area of efflorescence		22.3%

Source: Author's field report, 2011.

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APPENDICES

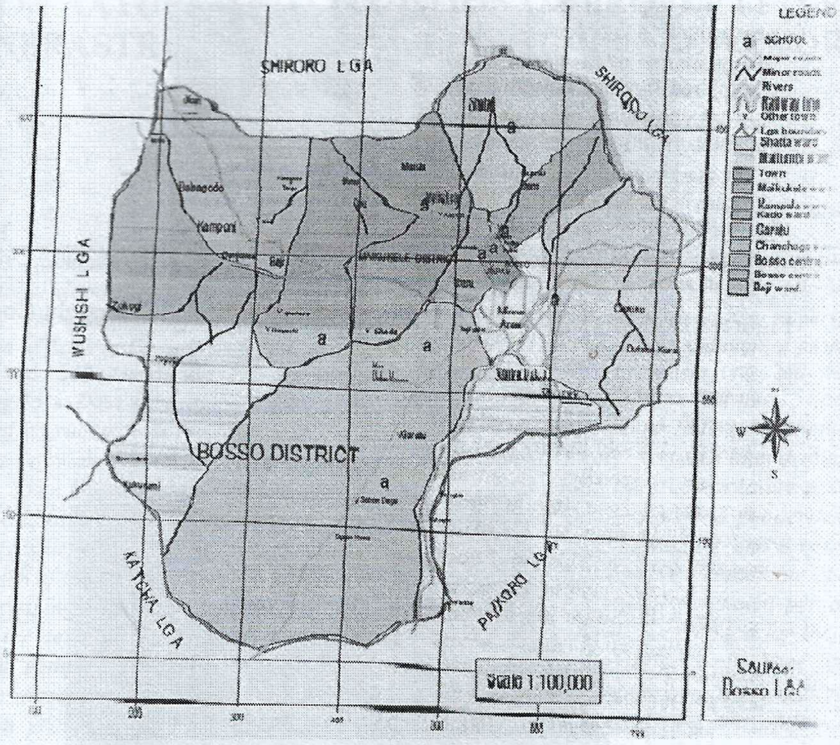

Figure 1. Map of study Area.

A THEORETICAL OVERVIEW OF SICK BUILDING SYNDROME IN THE BUILT ENVIRONMENT

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Abstract

The phrase 'Sick building syndrome' is very hazy and means many things to many people and thus the users and facility managers of the built environment attach less importance to the cause and upshot of this symptoms and illnesses due to shallow knowledge and understanding of the health challenge experienced in the building. The paper examines the notion explicitly. It identifies various symptoms of sick building syndrome, how a building gets to be sick and highlights the causes of sick building syndrome. The paper concludes that most building related illness is due to poor awareness of building users on the consequence of unhealthy activities, furniture and electrical gadget in the building that slowly release toxic vapours, gases and pollutants into the air at room temperature. The paper will be of great use to researchers, construction professionals, building users, built environment policy makers as well as students in the environmental studies.

Keywords: *built environment, sick building syndrome, Symptom, air conditioning, ventilation.*

Introduction

We spend around 90% of our time inside buildings breathing, living and working. Most modern day materials used in interior design and architecture contain toxic additives. These materials are harmful to human and animal health as they slowly release toxic vapours, gases and pollutants into the air at room temperature (off gassing). This creates indoor air pollution and low air quality levels. Interior air also becomes polluted through tobacco smoke, the use of space heaters, electrical equipment, appliances and chemical cleaning supplies. Interior air pollution is more damaging to human health than exterior air pollution as it is condensed and contained within small areas. Over time we may develop symptoms and illnesses such as sick building syndrome, asthma or allergies from indoor air pollution. (Holistic Interior Designs, 2011).

The Meaning of Sick building syndrome (SBS)

"Sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout the building. In contrast, the term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants.

Table 1 shows two types of syndrome; one is a more allergic response in sensitive individuals. In addition, the World Health Organization (1983) lists the following symptoms of malaise: eye, nose and throat irritation sensation of dry mucous membranes and skin erythematic mental fatigue headache high frequency of airway infection and cough hoarseness, wheezing, itching and unspecific hypersensitivity nausea, dizziness.

Natural and Artificial Ventilation: Air-conditioning systems

People working in air-conditioned buildings consistently show higher rates of sickness than those working in buildings that are naturally ventilated or that have mechanical systems of ventilation supplying ducted air but not cooling or humidifying it, although it may be pre-heated (Finnegan et al 1984; Robertson et al 1985; Burge et al 1987; Wilson and

Hedge 1987; Wilson et al 1987). For all ventilation categories, workers in public sector buildings have consistently higher rates of building-related sickness than those in the private sector (Wilson and Hedge, 1987).

A 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodelled buildings worldwide may be the subject of excessive complaints related to indoor air quality. Often this condition is temporary, but some buildings have long-term problems. Frequently, problems result when a building is operated or maintained in a manner that is inconsistent with its original design or prescribed operating procedures. Sometimes indoor air problems are a result of poor building design or occupant activities.

Many buildings are now designed to reduce the intake of 'fresh' outside air because it is cheaper to re-circulate air that has already been warmed up in winter, or cooled in the summer, than to take in outside air and heat or cool it. Doors, window frames and other seals in the building are made as air-tight as possible, windows cannot be opened, and the amount of outside air brought into the ventilation system may be reduced - perhaps to zero, so that only re-circulated air is being breathed. Such buildings are known as 'sealed' or 'tight' buildings. Sometimes air inlets have been found to be bricked up. And the power of fans that distribute air from the air handling unit into the distribution ductwork may be reduced, or some fans may be turned off altogether for periods of time to save on energy costs. (EPA, 1991).

Air-conditioning systems themselves can harbour pollutants and micro-organisms and so add to the contamination of the workplace. For example, dirt enters with the air supply and builds up in the ductwork over time, or may have been lying in the system since it was installed. Often there is no-one in an organisation who really understands how the systems work. In addition, maintenance and cleaning of systems seem to be the exception rather than the rule, through negligence or because the various parts of the system are inaccessible (Wilson et al 1987).

Syndrome and Symptoms

A syndrome is a group of symptoms that characterises a particular medical condition. Every person suffering from the condition may not have all the symptoms. Table 1 shows four syndromes that have been identified as being related to buildings. The symptoms that make up these syndromes are fairly common in any group of people, so it is their association with a particular building, and the fact that they improve after the person has left the building, that show the symptoms to be building related. It is often useful to keep a diary of symptoms, perhaps recording their severity on a scale of 0-7 every two hours for a week at work and throughout a weekend away from work.

Some of the symptoms are found in more than one syndrome, for instance lethargy and chest tightness, and the symptoms can be divided into four categories: Dryness of the skin, eyes, nose and/or throat allergic symptoms, such as watery eyes or runny nose asthmatic symptoms, such as chest tightness general feelings, such as lethargy, headache or malaise. Also it could be further observed from Table 1 that there exist two types of sick building syndrome; one is a probable allergic response. Not everyone would agree with this classification into allergic and non-allergic responses. sick building syndrome may consist of sub-syndromes based on reactions to chemicals or microbes. The symptoms particularly associated with the proposed chemical sub-syndrome include fatigue, headache, and dry and irritated eyes, nose and throat sometimes with nausea or dizziness. The most common to the proposed microbial sub-syndrome include itchy, congested or runny nose, itchy watering eyes, sometimes with wheezing, tight chest or flu-like symptoms. These symptoms fit with a presumed terminal nerve irritation mechanism in the case of chemicals, and an infective or allergic mechanism in the case of microbes.

Humidifier fever and occupational asthma are illnesses related to buildings but they are considered to be separate from sick building syndrome because their causes can more usually be identified. These syndromes are not as common as sick building syndrome, and it is not yet known whether some of the underlying causes might be common to all four syndromes.

Similarly, Legionnaires disease, is a building-related illness with a clearly identifiable cause (the bacterium *Legionella pneumophila*), unlike sick building syndrome which usually has non-specific causes. (Health & Safety Executive Booklet, MISC 150).

Table 1: Medical syndromes associated with buildings

SYNDROME	SYMPTOMS
Sick building syndrome **(Type 1)**	Lethargy and tiredness Headache Dry blocked nose Sore dry eyes Sore throat Dry skin and/or skin rashes
Sick building syndrome **(Type 2)**	Watering/itchy eyes and runny nose i.e. symptoms of an allergy such as hay fever
Humidifier fever	
(1) Flu-like symptoms	Generalised malaise Aches and pains Cough Lethargy Headache
(2) Allergic reaction in sensitive individuals	Chest tightness Difficulty in breathing Fever Headache
Occupational asthma	Wheeze Chest tightness Difficulty in breathing

Sources: World Health Organization 1983; Morris 1987; Wilson and Hedge 1987

Symptoms of Sick Building Syndrome

Since the symptoms of sick building syndrome are common in the general population, it is the pattern of their expression that points to the diagnosis: in sick building syndrome, symptoms are associated with being in a particular building and are relieved by leaving or staying away from that building.

The symptoms of sick building syndrome include eye and nose irritation, runny or stuffy nose, fatigue, headache, nausea, sore throat and general respiratory problems. Environmental tobacco smoke is often blamed for these symptoms, particularly since it can be seen or smelt, but many other less visible pollutants, as well as environmental conditions, can cause similar problems. For example, identical symptoms to those described above are suffered by people who are exposed to formaldehyde, ammonia, nitrogen oxides, cotton dust and fibreglass particles; by those who are allergic to dusts and microbial spores; and by those exposed to low relative humidity for long periods of time (Robertson et al, 1985).

The responsibility of the Built environment professionals

The number of different people and professionals involved in the design and construction of an average building provides much scope for poor decision-making leading ultimately to unhealthy working conditions (Vischer 1989). The developer might assign 'quality control' decisions to the architect, who is then at the mercy of the engineers brought in to design heating and ventilation systems and lighting. Architects are not engineers, so they have to rely on engineers' design specifications. Routine formulae are used to calculate air distribution systems throughout a building, and standard systems are cheapest to design and install. If specific user requirements are not known, or are not taken into account because of cost constraints, a standard system is installed which turns out to be inappropriate to the ultimate users of the building. In a similar way uniform lighting is often fitted, with little attention paid to the need for local lighting for particular tasks.

Architectural and engineering decisions may be made with little reference to each other. For instance, an attractive architectural space such as a high, glassed-in sunny atrium may have no means of exhausting the heated air that collects at the top of it. Once building starts, responsibility for quality control shifts by default to the contractor. Many changes are made as the building is constructed, so that design specifications are altered. For instance, chunks of concrete in the air mixing chamber of the ventilation system may be left there if the cost of their removal is too high. Concrete may not be given enough time to dry out before a screed coating is applied. Plastic parts may be substituted for metal ones in the ventilation ductwork if the specified parts cannot be obtained in time or are too expensive. Waiting for parts costs time and money, so short-cuts are taken.

Once the building has been constructed, the space is prepared for use. Walls and partitions are put up and finally equipment and machines are installed, often with no notice being taken of the siting of ventilation inlets and outlets or assumed pathways of air flow across a space. An office may be walled in with a supply air vent but no extract outlet. And to make matters worse the air-conditioning system may never be properly 'commissioned' by the installation engineer once the building has been occupied so that the system is not correctly balanced. A catalogue of errors and poor decisions may mean that problems are 'built in' to the structure, only to be added to by incorrect operation and poor maintenance.

Causes of sick building syndrome and building related illness.

Both SBS and BRI are caused by poor indoor air quality. These are the main factors that can cause or contribute to SBS or BRI:

1. Inadequate ventilation – poorly installed HVAC systems, insufficient air exchange rates.
2. Indoor chemical contaminants – carpeting, paints, wood products, pesticides, cleaning agents, indoor smoking etc.
3. Outdoor chemical contaminants – exhaustion fumes, building exhausts, combustion products.
4. Biological contaminants – mold, pollen, bacteria, insects and others.

In the discussions, much emphasis is placed on air-conditioning and ventilation systems since inadequate ventilation has been considered to be a causal factor in 50 per cent of sick buildings in the United States and in 68 per cent of Canadian investigations (Melius, 1984). However, precise causal factors are rarely found in sick building investigations. Many reports conclude that inadequate ventilation was the cause of sickness because no other factor could be found, and improving the ventilation helped to remedy the situation. But improving the ventilation would in turn reduce the amount of contamination with chemicals or micro-organisms, so that increased ventilation can be seen as an effective treatment rather than a cause. Despite numerous investigations, journal articles and conferences, little has actually been proven about the causes of sick building syndrome. Different experts have different theories - some say the main cause is chemicals, others that fungi are primarily to blame, or physical factors such as humidity, temperature or lighting, or the air-conditioning system itself.

In the USA, investigations carried out up to the end of 1983 by the National Institute for Occupational Safety and Health (NIOSH), a governmental organisation, showed 'inadequate ventilation' to be the causal factor in about half of buildings with health complaints (see Table 2). Inadequate ventilation was often given as the cause when no other, more precise, cause, could be found.

What is certain is that these symptoms are more common in buildings with air-conditioning or mechanical ventilation. Six building features are strongly associated with symptoms of sick building syndrome (McIntyre and Sterling 1982): A hermetically sealed, airtight shell mechanical heating, ventilation and air-conditioning systems use of materials and equipment that give off a variety of irritating and sometimes toxic fumes and/or dust fluorescent lighting that may produce photochemical smog application of energy conservation measures lack of individual control over environmental conditions.

Table 2: Types of problem found in indoor air quality investigations carried out by NIOSH

PROBLEM	NUMBER	PERCENTAGE (%)	NOTES
Contamination (inside)	36	18	Exposure to chemical or other toxic agent generated within the office space, e.g. methyl alcohol from spirit duplicator, methacrylate from a copier, sulphur dioxide from a heating system, amines used in a humidification system, chlordane used as a pesticide
Contamination (outside)	21	10	Exposure to a chemical or other toxic substance originating from a source outside the building, e.g. motor vehicle exhaust fumes, construction activity, underground petrol spillage
Contamination (building fabric)	7	3	Problems from the material used to construct the building (figure excludes asbestos), e.g. formaldehyde, fibreglass.
Inadequate ventilation	98	48	Symptoms may be due to low levels of multiple contaminants and/or poor ventilation
Hypersensitivity pneumonitis	6	3	
Cigarette smoking	4	2	
Humidity	0.9	4	
Noise/illumination	2	1	
Scabies	1	0.5	
Unknown	19	9	

Source: NIOSH (1983).

how to protect ourselves from sick building syndrome (sbs) and building related illness (bri).

A systematic approach is needed to determine which of these factors, or combination of factors, is likely to be responsible in a particular building. It is easy to throw money at a building without improving things at all. Therefore, the following steps might be taken to solve sick building syndrome (London Hazards Centre, 1990; EPA, 2010).

1. Pollutant source removal or modification is an effective approach to resolving an IAQ problem when sources are known and control is feasible. Examples include routine maintenance of HVAC systems, e.g., periodic cleaning or replacement of filters; replacement of water-stained ceiling tile and carpeting; institution of smoking restrictions; venting contaminant source emissions to the outdoors; storage and use of paints, adhesives, solvents, and pesticides in well ventilated areas, and use of these pollutant sources during periods of non-occupancy; and allowing time for building materials in new or remodelled areas to off-gas pollutants before occupancy. Several of these options may be exercised at one time.
2. Increasing ventilation rates and air distribution often can be a cost effective means of reducing indoor pollutant levels. HVAC systems should be designed, at a minimum, to meet ventilation standards in local building codes; however, many systems are not operated or maintained to ensure that these design ventilation rates are provided. In many buildings, IAQ can be improved by operating the HVAC system to at least its design standard, and to ASHRAE Standard 62-1989 if possible. When there are strong pollutant sources, local exhaust ventilation may be appropriate to exhaust contaminated air directly from the building. Local exhaust ventilation is particularly recommended to

remove pollutants that accumulate in specific areas such as rest rooms, copy rooms, and printing facilities.

3. Air cleaning can be a useful adjunct to source control and ventilation but has certain limitations. Particle control devices such as the typical furnace filter are inexpensive but do not effectively capture small particles; high performance air filters capture the smaller, respirable particles but are relatively expensive to install and operate. Mechanical filters do not remove gaseous pollutants. Some specific gaseous pollutants may be removed by adsorbent beds, but these devices can be expensive and require frequent replacement of the adsorbent material. In sum, air cleaners can be useful, but have limited application.
4. Education and communication are important elements in both remedial and preventive indoor air quality management programs. When building occupants, management, and maintenance personnel fully communicate and understand the causes and consequences of IAQ problems, they can work more effectively together to prevent problems from occurring, or to solve them if they do.
5. You should obtain as much information as possible; particularly examples of other cases of sick building syndrome you have had to deal with. Talk to as many people as possible to elicit their opinions on the working conditions, symptoms and possible causes.

Conclusion

This paper has been able to examine the meaning of sick building syndrome in the built environment and identified that professional have an immense role to play in design and construction to keep the building users safe and in good health.