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TECHNICAL NOTE #4

Health Aspects in Buildings

VOCs and Clay Brick Masonry Walling

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Title

A review of the Health Aspects in buildings as pertaining to Volatile Organic Compounds (VOCs) and Clay Brick Masonry.

Status

This Technical Note is provided as an information sheet for appending to the ClayBrick.org website.

Scope

Review literature for the advantages of building with Clay Brick and improving indoor air quality

Methodology

A review of reports tabled at the SB10 and SB11 conferences reveals that there are advantages for the health of building occupants living in structures, which are built with clay brick. This is supplemented with a web based literature search of current indoor air quality and VOC papers.

Review of Health Aspects in Buildings as pertain to VOCs and Clay Brick Masonry Walling

Introduction to Indoor Air Quality (IAQ)

As people spend approximately 80-90% of their lifetime indoors, the health and physical well-being of building occupants is therefore important, particularly for the young and the aged. Harmful chemical substances in the indoor air, dust and mould spores, high levels of carbon dioxide, cigarette smoke, and odours from cooking or cleaning detergents can lead to long term health problems. Furthermore, the use of certain building materials, furniture or floorings can be responsible for toxic emissions, which compromise Indoor Air Quality.

The aspect of room temperature (local comfort conditions varying between 19-26°C) and humidity (40-60%) is also essential for human wellbeing, and has a bearing on energy usage for artificial heating or cooling.

The reduction of heating and cooling demand and the improvement of energy efficiency of buildings has recently become a goal of new buildings in South Africa. Architects are also increasingly focusing on a holistic integrated approach to healthy living, including air quality - an area that was previously the preserve of mechanical engineers. For building occupants, energy efficient living does not constitute a dominant priority, but the quality of living represents their main priority.

Other aspects to indoor air quality include asbestos fibres, biological pollutants, carbon monoxide, formaldehyde (in the main from particle-board), lead, nitrogen dioxide, pesticides, radon, respirable particles, second hand smoke, including tobacco smoke, and emissions from stoves, heaters, fireplaces, and chimneys, spores derived from mould growth and Volatile Organic Compounds (VOCs).

“Sick Building Syndrome” describes the situation which is derived from poor indoor air quality and is diagnosed when several persons living or working in the same building complain of similar symptoms of illness such as irritations of conjunctiva, nasal and throat mucous membranes, reddening, itching, sneezing, headaches, dizziness and tiredness. Furthermore, hypersensitivity or allergy-increasing characteristics, particularly carcinogenic, mutagenic or toxic for reproduction properties may lead to long-term effects. The “Sick Building Syndrome” applies when the percentage of people showing these symptoms is higher than that in comparable buildings.

Volatile Organic Compounds

Since VOC's are emitted as gases from certain solids or liquids, and also certain chemicals, these could result in short and long-term adverse health effects, such as lung disease and even cancer. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors.

VOCs are emitted by an array of products, including, paints and lacquers, paint trippers, cleaning supplies, pesticides, building materials such as carpeting, rugs, fabrics, compressed wood products, paints, sealants, solvents, wood stains, PVC and synthetic leather. Office equipment such as copiers, printers, correction fluids, carbonless copy paper, craft materials e.g. adhesives, permanent markers also emit VOCs. All contain organic (carbon-based) chemicals of low boiling point, which can off-gas to produce noxious fumes. Liquid and gaseous fuels are also made up of organic chemicals.

The two main types of pollution resulting from the release of VOCs are as follows:

- **Indoor Air Pollution**
  When VOCs are released into indoor air, they contribute to poor indoor air quality which can adversely impact human health by contributing toward ailments like headaches, asthma, dizziness, mood disorders, itchy eyes, nose, or throat, nausea, liver, kidney, or central nervous system damage, allergic skin reactions, fatigue, visual disorders and even cancer.

- **Outdoor Air Pollution**
  When released outdoors, VOCs contribute toward the problem of smog or ground level ozone pollution when they react with other chemicals in the presence of light.

The US Environmental Protection Agency (EPA) Office of Research and Development's, "Total Exposure Assessment Methodology (TEAM) Study" found levels of almost a dozen common organic pollutants to be 2-5 times higher inside homes than outside, regardless of whether the homes were located in rural or highly industrial areas. TEAM studies indicated that while people are using products containing organic chemicals, they can expose themselves and others to very high pollutant levels, and elevated concentrations can persist in the air long after the activity is completed indoor air quality issues in general.

Acetone, Butane, Chlorofluorocarbons, d-Limonene, Ethanol 2-propanol, Fire retardants like PCBs and PBBs, Formaldehyde, Hexanol, Methyl chloride, Methyl tertiary-butyl ether (MTBE), as well as pesticides such as DDT, Plasticizers such as phthalates, Propane, and Toluene are examples of VOCs. Some VOCs are generated during normal natural processes, such as by plants through biosynthesis, as for the aromatic scents of the fynbos, pine and eucalyptus plantations.

Volatile Organic Compound Concentration Measurement

The US Environmental Protection Agency regulates VOC outdoors mainly because of their ability to create photochemical smog under certain conditions by preventing the formation of ozone. Although the same term “VOC” is used for both indoor and outdoor air quality, the term is defined differently to reflect its predominant concern in each context. This has created a misunderstanding in the marketplace and in the environmental community. Furthermore, the measured quantity and composition of VOC in the air can vary significantly depending on the measurement methods used, which has generated additional confusion.

A VOC is any organic compound having an initial boiling point of less than or equal to 250°C measured at a standard atmospheric pressure of 101.3kPa. VOCs are sometimes categorised by the ease in which they will be emitted. For example, the World Health Organization (WHO) categorises indoor organic pollutants as very volatile, volatile, and semi-volatile. The higher the volatility of the material the lower is the boiling point and the more likely the compound will be emitted from a product or surface into the air. Volatility is indicated by a substance's vapour pressure, which can be the tendency of a substance to vaporise, or the speed at which it vaporises. Substances with higher vapour pressure will vaporise more readily at a given temperature than substances with lower vapour pressure.

Measurement of VOCs in Indoor Air

Legal requirements for indoor air quality are part of the new European Union Construction Products Regulation. The basic requirements of these regulations deal with the hygiene, health and environmental aspects of construction products throughout their lifecycle.

The toxic gases, VOCs, greenhouse gases or dangerous particle emissions to or radiation into indoor air during the construction, use and demolition of buildings is also required to be disclosed. These requirements are related to the respective harmonised standards of CEN Technical Committee 351 and will be required to be detailed in construction products standards.

Knowledge about the VOCs that are present at low concentrations normally found in indoor air in any given situation is highly dependent on how they are measured. All available measurement methods are selective in what they can measure and quantify accurately, and none are capable of measuring all VOCs that are present. For example, aromatics such as benzene and toluene are measured by a different method than formaldehyde and other aliphatic compounds.

The range of measurement methods and analytical instruments is large and will determine the sensitivity of the measurements as well as their selectivity or biases. This is why any statement about VOCs that are present in a given environment needs to be accompanied by a description of how the VOCs were measured so that the results can be interpreted correctly by a professional. In the absence of such a description, the statement would have limited practical meaning.

Labelling of Products

It is important for consumers to understand that information on labels or other product literature with broad claims about environmental impact using terms such as “green” or “environmentally friendly” may or may not include some of the VOCs emitted from the product, and therefore may not otherwise consider their adverse health effects.

There are however, national and international programs that certify and label products and materials based on their indoor air quality impacts, such as various human health and comfort effects, including odour, irritation, chronic toxicity, or carcinogenicity. Such programs are likely to include consideration of at least some of the VOCs of concern for indoor air. However, the norms and requirements currently used within the product labelling and certification industry for indoor products are not standardised.

The government or third-party organisations have not as yet established the ground rules to craft consistent, protective standard test methods to rate and compare products and materials. This lack of standardisation makes it difficult for the consumer and also design experts to fully understand what the labels and certifications mean in most cases.

The Natureplus® quality seal stands for health awareness, environmentally-friendly production, the protection of limited resources and suitability of application. Building materials that carry this seal are characterised by particularly high standards for health, environment and functionality. Austrian clay bricks and roof tiles producers have had a major portion of national production certified according to the Natureplus® scheme.

The “Healthy Brick Building“ in Thalheim, Germany built by KHB - Creativ Wohnbau GmbH in 2008 was the first single-family home certified by the Sentinel-Haus® Institut. The building method was a monolithic clay brick construction with a concrete basement. The U-value of the external walls is 0.28 W/ (m^2/K). Due to a careful choice of construction products and the healthy living concept of the SentinelHaus ® Institut, the results of the measurements of the indoor air quality conducted by independent testing institutes were extremely positive:

- Formaldehyde 7µg/m^3 achieved (60µg/m^3 required)
- TVOC 300µg/m^3 achieved (1.000µg/m^3 required)

Several certified bodies that test building products for VOC levels (among other aspects), in the US include Green Seal, GREEN GUARD, Cradle to Cradle, and Scientific Certification Systems.

VOC Regulations and Choice of Material

A study by the Austrian Institute for Healthy and Ecological Building has been undertaken to develop a comprehensive system to prevent the use of materials containing toxic pollutants in the indoor air of a building. The possible risk exposure of certain building materials was assessed according to this system during the planning phase. The study concentrated on the impact of building materials on the indoor air quality in terms of VOCs, and on emissions during the use of a building. This was with relevance to multi-storey residential buildings, on new buildings and preventive measures.

The study tried to develop rating schemes for healthy buildings, which could be used by authorities inter alia for housing subsidies. For this, purpose the Institute classified construction products in three different groups, according to its relevance for indoor air quality during the use phase.

Level 0:	Construction products which are not - or only for a very small part - responsible for VOCs in the indoor air, e.g. those based on mineral raw materials like high mass construction products (concrete and masonry).
Level 1:	Construction products containing a low amount of organic additives are emitting toxic pollutants, e.g. untreated solid wood, windows and inner doors made of wood.
Level 2:	Construction materials which extensively use chemicals, such as polymer-based floorings and wooden composites, as well as other treated materials, which are responsible for the emission of toxic pollutants.

The study by the Austrian Institute for Healthy and Ecological Building comes to the conclusion that the best route for achieving a healthy indoor air quality is the so-called “Construction products management" method. This requires for careful selection of the building materials (as per Specifications and Bills of Quantities) and continuous quality controls at the construction site.

The successful implementation of the criteria must be documented by experts and supplemented with an additional test of indoor air quality. Thus an avoidance of pollutants to indoor air requires the avoidance of problematic constituents in the construction product selection.

Some VOC labels or certification programs are based on the VOCs emitted from the product into the indoor environment and possible related health impacts. However, some are based on the content of VOCs that are regulated to control the formation of photochemical smog outdoors.

Therefore, VOC labels and certification programs may not properly assess all of the VOCs emitted from the product, including some chemical compounds that may be relevant for indoor air quality. This is especially true of most wet products, such as paints or adhesives that may be labelled as “low-VOC” or “zero VOC”. Specifiers should be aware on this detail.

Assessment Methods and VOCs

The Total Quality Building (TQB) certificate in Austria has been developed by the Austrian Institute for Healthy and Ecological Building as the comprehensive solution for an integrated and sustainable building assessment in Austria.

The TQB assessment tool for residential buildings consists of five assessment categories, each weighted with a maximum of 200 points, with an overall maximum of 1000 quality points achievable for one building:

- Location and infrastructure
- Economical aspects and technical quality
- Energy and supply
- Health and comfort
- Resource-efficiency.

The indoor air quality of a building can secure 50 points.

Most Green Buildings assessment systems (LEED, BREAM, Green Star, and the Green Building Council of SA rating tools will make provision for a portion of the points on offer to be secured with attention to the low VOC aspects.

The General Directorate for Health and Environment of the European Commission relies upon the work of SCHER (Scientific Committee on Health and Environmental Risks) regarding its assessment of indoor air quality, and according to the German Sentinel-Haus® Institut there are six different causes for unhealthy buildings which can be separated:

- Building materials
- Causes due to construction (e.g. construction mistakes)
- Minimised air exchange
- Causes due to behaviour
- Causes due to the environment and products from industrial chemical applications.

Furthermore, advice for the healthy choice of materials for floors, walls and ceilings, paints and varnishes and furniture is given by the Austrian Institute of Healthy and Ecological Building. The use of wood, which for a long time has been considered as the perfect natural building material brings with it preservatives and pesticides (chromium and arsenic containing), which can cause health problems. Inorganic building materials however such as bricks, whitewash, plaster roughcasts and artificial stone do not normally cause health problems.

According to the German research project “Building Products: Determining and avoiding pollutants and odours” issued by the German Umweltbundesamt and the Technical University Berlin, only insignificant or minuscule emissions of VOCs can normally be expected from the following building materials: Traditional building products like masonry units, full-mineral mortars, steel or glass.

Synthetic materials contain a number of inorganic and organic additives such as softeners or flame retardants. Natural organic products, such as wood contain waxes and oils, which contain a variety of organic compounds, like resins, and solvents. Natural products do not imply that they are free from pollutants.

Conclusions

Reducing the concentration of VOCs indoors and outdoors is an important health and environmental goal. However, it is important to understand that there are VOCs of concern indoors and outdoors that do not impact photochemical oxidation and therefore are not regulated by the EPA.

It is important to make and understand this distinction when advocating or using strategies to improve indoor air quality.

For indoor air quality, all organic chemical compounds whose compositions give them the potential to evaporate under normal atmospheric conditions are considered VOCs and should be considered in any assessment of indoor air quality impacts.

It is noted that by building with Clay Brick and by giving attention to a low VOC requirement for the paint specification, that designers will be able to ensure a very low level of VOC in buildings.

References

1) Indoor Air Quality – A new important criterion for the sustainability of houses, Gerhard Koch General Secretary Austrian Association of Clay Bricks and Roof Tiles Manufacturers Austria, koch@ziegel.at

2) Code of Federal Regulations, 40: Chapter 1, Subchapter C, Part 51, Sub-part F, 51100 and EPA Terms of Environment Glossary, Abbreviations, and Acronyms.

3) Directive 2004/42/CE of the European Parliament and the Council, EUR-Lex. European Union Publications Office.