



International Conference on Sustainable Design, Engineering and Construction

## Perception of indoor environment quality in differently ventilated workplaces in tropical monsoon climates.

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### Abstract

Quarter of the global greenhouse gas emissions are related to generation of electricity by combustion of fossil fuel. Office buildings are one of the highest energy consumers of the built environment, employing over half of its end use energy for heating, ventilation, air conditioning and lighting. The intense solar radiation received in the equatorial regions requires that cooling and dehumidification provided inside buildings at all times to achieve comfort. Comfort is a strong indicator of workplace satisfaction which further influences productivity. The research investigates the perception of indoor environment quality (IEQ) in differently ventilated workspaces and the applicability of each ventilation type in the tropical monsoon climate. The surveyed utilized a seven point unipolar and bipolar scale to measure occupant's subjective evaluation of the indoor environment condition. Valid responses were collected from 523 participants of nine office buildings in Colombo, Sri Lanka. The buildings were categorized into three ventilation types for analysis: central air Conditioning (AC), ductless mini split system air conditioning (MM), naturally ventilated with operable windows and fans (NV). The perceived performance of AC and MM buildings were found to be similar in IEQ aspects; overall comfort, temperature comfort, temperature sensation, satisfaction with amount of natural light. AC and MM buildings were rated more satisfactory for overall comfort of indoor environment condition. The investigation reinforce the need for holistic, bottom up approach to design of environmentally sustainable office buildings.

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Peer-review under responsibility of organizing committee of the International Conference on Sustainable Design, Engineering and Construction 2015

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*Keywords:* green office, indoor environment quality, comfort, ventilation

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## 1. Introduction

Climate change, unacceptable pollution levels and depletion of non-renewable resources has made sustainable development a key research and policy issues. Quarter of the global greenhouse gas emissions are attributed to generation of electricity by combustion of fossil fuel [1]. Seventy percent of global end use energy consumption is directly or indirectly related to buildings and infrastructure [2]. Office buildings are one of the largest energy consumers in the built environment, and spends over 50% of its end use energy for heating, ventilation, air conditioning and lighting. The climate of Sri Lanka induced by monsoon winds features constant high temperatures (at sea level and low elevations) and high humidity throughout the year. In such hot humid climates the challenge is to reduce solar heat and humidity in buildings. The optimum thermal comfort conditions based on Fanger's heat balance equation [3] requires that cooling and de-humidification provided inside building at all times to achieve comfort in Sri Lanka. Contrary to this claim three ventilation types are commonly employed in office buildings in the region; central air conditioning, ductless mini split system air conditioning and natural ventilation with operable windows and fans. This paper investigates the perception of indoor environment quality (IEQ) in differently ventilated workspaces and the applicability of each of these ventilation types in the tropical monsoon climate.

### 1.1. Literature Review

Buildings are a sensory experience. Environmental stimuli are senses via distinct sensory organs hosting sensory receptors; eyes, ears, nose, tongue, skin etc. Further there are unconscious senses namely kinaesthetic sense, receptors in the digestive and circulatory systems, sense of balance and equilibrium in the human inner ear [4]. Information received at these sensory receptors are transmitted to the brain through nerve cells and higher-order neurons as a nerve impulse. The nervous system, endocrine system and immune system regulated by the human brain manage, control and produce responses and symptoms to information received by sensory receptors. There are four basic environment factors which directly influence human perception of that indoor environment through the senses; thermal comfort, lighting quality, indoor air quality and acoustical quality. External stress generated by these environment factors influence the nervous system, immune system and endocrine system resulting in, discomfort, systematic effects of tiredness and poor concentration, psychological effects of depression and anxiety, allergic and hyper-reactive effects, infectious diseases and long term exposures may result toxic and chronic effects. Apart from environmental stress factors, internal stress factors such as age influence human senses due to degradation of the eyes, ears and olfactory bulb etc. A comfortable indoor environment is where there is exemption from unwanted environmental stress and one that allows the designated function to occur unhindered physically or mentally [5].

The condition of the indoor environment is a product of the climate, location, and design of the building shell and interior. And the influence of the indoor environment on occupants are further modified by physical and psychosociological factors. Field surveys of thermal comfort in the tropics realized that the conditions which people find comfortable differed from the predictions of thermal comfort standards which were based on Fanger's heat balance equation [6-11]. Nicol and Humphreys link these differences in optimum comfort conditions to feedback between the comfort of the subjects and their behavior, which allow adaptation to the climatic conditions where the surveys were conducted [12]. They further identified climate as the prime contextual variable which influence the thermal attitudes of people; whilst the basic mechanism of the human relationship with the thermal environment stay uniform in different climates. Climate influences the culture and design of buildings people inhabit; in variable

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