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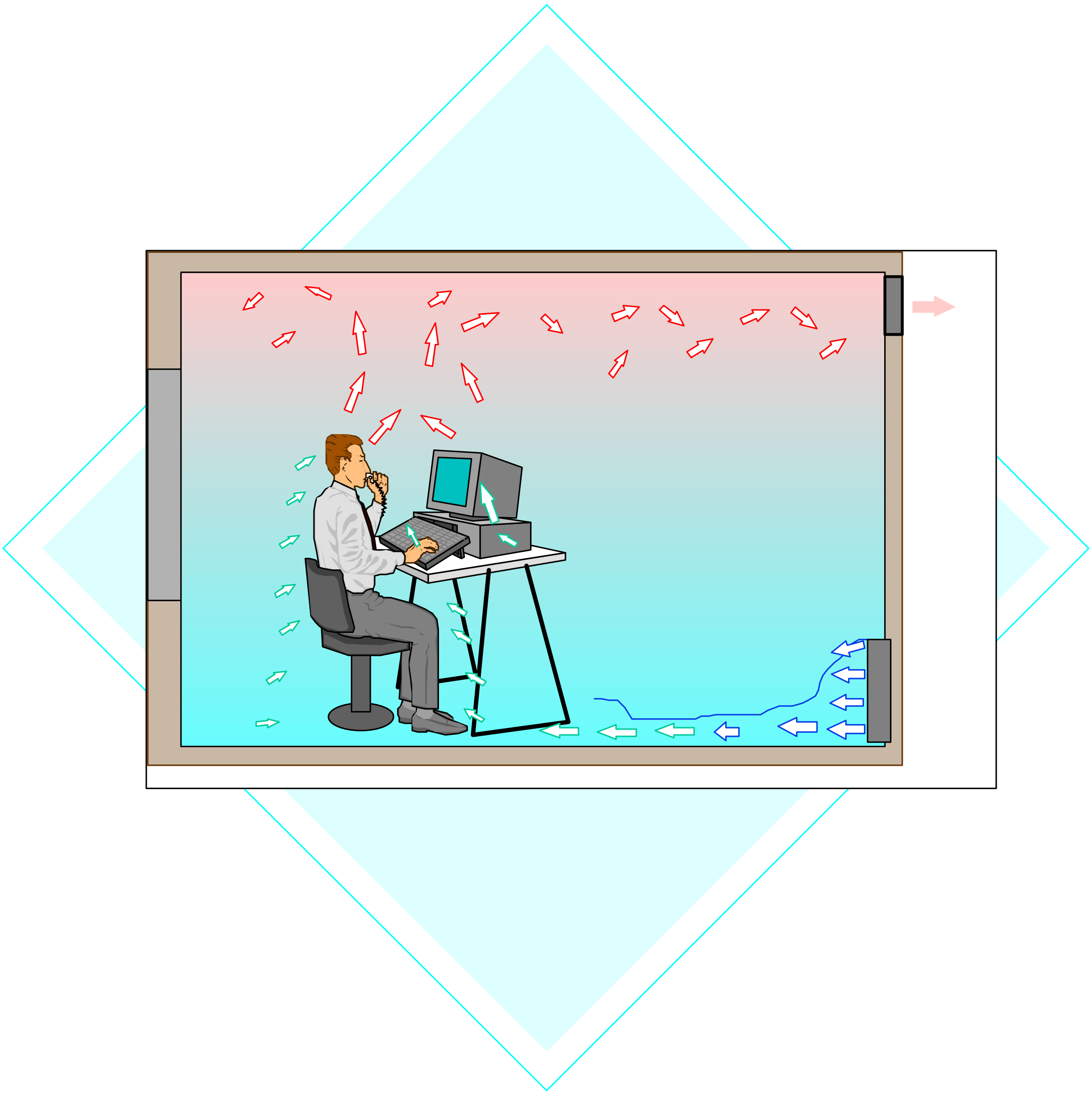
DISPLACEMENT VENTILATION AND STATIC COOLING DEVICES

Tariq Abbas



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Tariq Abbas

The Building Services Research and Information Association
Old Bracknell Lane West,
Bracknell, Berkshire RG12 7AH
Tel: + 44 (0)1344 426511 Fax: + 44 (0)1344 487575
e-mail: bsria@bsria.co.uk www.bsria.co.uk

BSRIA

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EXECUTIVE SUMMARY

The characteristic of a displacement ventilation system is the provision of fresh cool air directly into the occupied zone at a speed and temperature that does not cause discomfort. Once the air enters, it spreads across the floor forming a reservoir of fresh cool air. The movement of air within the space is primarily buoyancy driven such that heat sources (particularly people) generate vertically rising thermal plumes which entrain surrounding air. The 'reservoir' of fresh cool air at floor level flows to replace that which was warmed and lifted into the thermal plume. The overall result is a vertical stratification of temperature and pollutant concentration such that the best conditions are achieved and maintained in the occupied zone.

Displacement ventilation systems are a viable alternative to conventional air conditioning and ventilation systems and offer the potential for better internal conditions alongside significant energy savings. However, these achievements will only be realised through good design practice, which in turn relies on a comprehensive knowledge of the design issues.

This document presents a detailed description of how displacement ventilation systems work, applications where it can be used, design issues, calculation procedures, system performance in terms of temperature, air speed, thermal comfort and indoor air quality as well as control, installation and maintenance.

The aim of this document is to recommend good, accepted practice for the design and implementation of displacement ventilation systems with and without static cooling devices and is based on previous and current research as well as the views of consultants and manufacturers considered to be experts in this field.

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GLOSSARY OF TERMS

STRATIFIED	Comprised of successive layers
PASSIVE (BEAMS)	Not involving forced air flow
DOWNDRAUGHT	Descending air caused by local cooling, especially from windows
REVERBERATION CHAMBER	A sound measuring room specially designed to facilitate the production of diffuse sound fields
GENERATED NOISE	Noise that results from turbulent air flow fields which become concentrated into a discrete region
ENTRAINMENT	Entrainment of air is the process by which air is drawn along a flow path by virtue of viscous shear forces. This term is synonymous with induction.
COANDA EFFECT	Specifically: Tendency for an air jet to attach itself to a solid convex body as a result of the pressure variation that is created perpendicular to the curved streamlines, named after the Rumanian engineer Henri Coanda. This phenomena results from a force acting towards the centre of curvature. Colloquially: It is often misquoted as the reason for wall jet attachment, which has nothing to do with curved surfaces. The 'Coanda effect' here refers to the situation where one side of a jet is close to a large solid surface. The supply of air for entrainment on the wall side of the jet is restricted, resulting in a partial vacuum. Hence, the jet remains attached to the solid surface. We shall continue to refer to this phenomenon as the Coanda effect in this document for reasons of continuity only.
TREATED SPACE	A volumetric portion of the enclosure starting from floor level and ending at a specific height. This specific height is the point where air entering the volume is equal to the amount of air leaving. The treated space is usually designed to be a volume that at least encompasses the occupied zone.
ATD	Air Terminal Device
IAQ	Indoor Air Quality
STRATIFICATION HEIGHT	Height to top of treated space.
PNC	Preferred Noise Criteria. Refers to a set of rating curves derived in the USA to assess the acceptability of HVAC plant noise

1 INTRODUCTION

The aim of any ventilation system is to provide air to an indoor space in an efficient manner so as to create a comfortable and clean indoor climate for the occupants.

Generally, there are two ways to ventilate a space. The traditional option is known as a mixing ventilation system which is based on the philosophy of continual dilution of stale warm air from a fresh supply. The ventilation air may be provided by an air conditioning system in which the air will typically be supplied at 12°C to 14°C. To encourage mixing, the air is supplied at high velocity and with a high degree of turbulence. A feature of this system is that conditions within the enclosure are considered to be predominantly uniform.

The second method, namely displacement ventilation, intends to keep new and stale air separated and involves introducing the air at low speed directly into the occupied zone at a temperature usually slightly lower than the room temperature. A feature of this system is that the supply air spreads across the floor forming a ‘reservoir’ of fresh cool air. This reservoir of air is in contact with heat sources (particularly people) and gets warmed so that it is lifted directly up and along the person and some is breathed en route to the plume that develops over the head, rising to a height of some 2 m to 2.7 m above the head. The warm stale air is extracted at the highest point. As a result, a temperature and contamination stratification of the air exists within the enclosure. The restriction to the supply air temperature limits the cooling capacity of the ventilation system and static cooling is often used to augment this.

The comparative merits of both systems have been the subject of considerable debate in recent times[Ref 1] primarily due to the gain in popularity of displacement air systems. The reason for this change probably lies in the drive to design buildings that consume less energy whilst maintaining good indoor air quality and thermal comfort.

The aim of this document is to recommend good, accepted practice for the design and implementation of displacement ventilation systems with and without static cooling devices and is based on previous and current research as well as the views of consultants and manufacturers considered to be experts in this field. It is an advisory document not intended to provide objective criteria by which compliance may be judged. The code of practice is not intended to reflect any single viewpoint, but highlights current thinking on the application of displacement ventilation systems with and without static cooling devices.

An outline of the various sections is provided in Table 1 below.

Table 1
Outline of content

Chapter Title	Issues covered
2. Design Concept	Describes the operational principles of displacement ventilation systems and static cooling devices.
3. Applications	Describes the main application areas and presents a brief overview of the past, present and future for displacement air systems.
4. Design Considerations	What should be considered before and after selecting a displacement air system.
5. Design Procedure	Presentation of design calculations with examples.
6. Performance	What should be expected from a displacement system with and without static cooling devices in terms of IAQ and thermal comfort.
6. Controls	How these systems can be operated.
7. Installation & Maintenance	How to keep these systems running.