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How thermal mass and heat recovery keeps it cool at the Simon Sainsbury Centre

HYBRID VENTILATION PERFORMANCE REVEALED CPD – USING SOLAR SHADING TO REDUCE OVERHEATING

April 2018



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Room to breathe



The need to meet stringent energy targets is an opportunity for engineers to develop innovative solutions, specific to each site and tailored to the occupants.

By moving away from the one-sizefits-all approach of sealed spaces with air conditioning, Arup's mixed-mode design of the Simon Sainsbury Centre - part of the University of Cambridge Judge Business School - gave users freedom of control over their environment.

Despite the noisy road on one side

of the building, designers decided to cross-ventilate spaces using 60 heat recovery units integrated into the façade, to draw fresh air into the building even on the hottest days. In the summer, users can open windows, but - if it is too cold or noisy - closing the windows automatically enables the room's heat recovery devices. See page 4.

Getting the ventilation strategy right is imperative for occupant comfort. On page 7, BAM Construct UK reports the results of its post-occupancy evaluations in four schools with local air recirculation units. It concludes that the technology is effective in achieving acceptable comfort conditions in classrooms. When using natural and hybrid ventilation, designers must also meet noise limits set out in BB93 Acoustic design of schools (page 9).

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Applying solar shading to reduce overheating in buildings

LIZA YOUNG, DEPUTY EDITOR lyoung@cibsejournal.com

Making an educated choice



Education is the most important part of the lives of young people and, for this reason, ensuring the reliability of buildings used for this purpose is vital. Facilities managers within schools, colleges and universities should be able to dedicate budget and attention to improving

the learning spaces, rather than carrying out repair work.

For new buildings, designing reliable, durable pipework systems for heating, hot and cold water, drinking water and gas is key to keeping the whole life cost of running and maintaining the property to a minimum

Beyond the original design of the system, repair and refurbishment in educational facilities presents particular challenges.

Any failure in the heating or supply of water means the school has to close and cannot reopen until it has been fixed. Addressing an issue quickly and with minimum disruption to the

activities of the building occupants is, therefore, an important consideration.

As with all building systems, selecting the most suitable material for the pipework is important; however, the most common source of issues for new buildings is failure of the joint. Modern press-connection systems offer a reliable, clean, fast and safe method for a range of applications. Furthermore, recent innovations now allow press-connection technology to be used on thickwalled steel tube - commonly used where added longevity and durability is required.

With the budgets of educational facilities under increasing pressure, it is more critical than ever that building systems are as reliable as possible - allowing staff and students to focus on what is important.

SCOTT JAMES director at Viega

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Breath of fresh air

Arup's innovative ventilation strategy not only preserved the aesthetic of the Simon Sainsbury Centre in Cambridge, but also exploited the building's thermal mass. Arup's **Joshua Bird** explains

hen it comes to energy efficiency, we demand more than ever before from our buildings. This does not, however, necessitate the one-size-fits-all approach of sealed spaces with air conditioning. A new generation of buildings can give occupants freedom of control over their environment and a connection to the outdoors. The need

to meet stringent energy targets should be an opportunity for engineers to develop novel solutions, specific to each site and tailored to the building users.

An example of these principles in practice is Arup's recent work on the Simon Sainsbury Centre, part of the University of Cambridge Judge Business School. The 5,506m² new development will allow the school to operate more efficiently and provide space for its growth.

The site was located between an existing building and a busy one-way road into the city centre. A shallow plan gave the designers the opportunity to cross-ventilate spaces, but the noisy road meant they could not always rely on occupants to manually open the windows on warm days. The answer was to integrate 60 heat recovery units into the façade to draw fresh air into the building even on the hottest of days. It was the first time this had been done in the UK at this scale.

A concrete structure gave designers the opportunity to use thermal mass to cool the building and, after extensive modelling to minimise solar gain, Arup came up with a services strategy that required minimal air conditioning.



The Cambridge Judge Business School embraced its ambitions to kick-start a site-wide masterplan and create a stateof-the art teaching facility. An architectural vision to showcase the concrete structure of the building presented an opportunity for storing heat, while lowering energy consumption. A constrained and slender site has become an opportunity to move away from sealed, mechanically ventilated spaces towards a flexible and personcentric solution.

The school was founded more than 25 years ago, as part of the Grade II-listed, John Outram-redesigned Addenbrooke's building in the historic centre of the city. While the existing buildings formed an important part of the school's identity and character, they no longer offered sufficient space – or appropriate facilities – for its current and future needs.

A collaborative approach

Arup has a close working relationship with architects Stanton Williams, and was thrilled to be commissioned to enhance, consolidate and expand the school's facilities on its existing site.

Arup led on the building services design for the Simon Sainsbury Centre, complementing a strong architectural vision for the extension, and ensuring a comfortable environment, minimal energy consumption, and flexibility.

The building is a striking collection of spaces – a testament to an architectural vision conceived and executed with attention to detail. It was completed in October 2017, with students and executive education delegates arriving in January 2018.

3D environmental modelling

Arup's first priority was to optimise, within the constraints of the site, the building's glazing, shading and fabric performance. Using a 3D model, it simulated the impact of solar gains on various façade options, and offered guidance on the position of solar panels, the benefit of shading elements, and the differing performance – G-values – of the glazing, depending on the orientation.

Limiting the solar gains into the offices was the first step in ensuring all spaces operate without the need for active cooling. Arup modelled the building's performance in various climate-change scenarios against the university's comfort criteria and the industry



"Arup has been able to offer the client guidance on space flexibility, allowing the building to adapt in the future"

standard TM52, to estimate the risk of overheating. The thermal mass of the exposed concrete soffits is used to full effect, together with a night purge. During the warmer summer months, the ventilation system cools the structure during the night. This regulates the temperature throughout the day, reducing the peak temperature experienced by the occupants.

Arup also simulated the effect of partially covering the concrete soffit, and considered using phase change materials to introduce additional thermal mass to reduce the need for air conditioning. However, detailed computer modelling and





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>>> liaison with a manufacturer determined that the materials available on the market would not regulate the temperature of the building on the hottest of days. 3D modelling at this early stage in the design process and throughout the project allowed for clearer coordination of services.

Low energy, natural ventilation

The client wanted to avoid active cooling - or air conditioning - wherever possible. With its long-form, shallow floorplan and doubleaspect spaces, the site was suited to a natural ventilation strategy. However, it sits adjacent to Tennis Court Road, a one-way street that can become noisy, so relying solely on natural ventilation could have proved disruptive at certain times. The teaching spaces are more intensively used, so these are actively cooled and mechanically ventilated. These spaces are on the ground floor, next to the plantrooms. For the remainder of the building, Arup's response was to design a mixed-mode building, capable of being ventilated mechanically or naturally. In the summer, users can open the windows. But if it is too cold or noisy, closing the windows automatically enables the room's heat recovery devices.

The Simon Sainsbury Centre is the first building in the UK to employ the Schoolair low energy ventilation system, designed by Trox Germany, with more than 60 heat recovery units integrated into the façade throughout the building. It uses 10 times less fan energy than a conventional ducted system and, by omitting any high-level ducts, Arup could preserve the clean aesthetic of the building's exposed concrete soffits. This approach reduces the in-use energy consumption and has allowed the building to exceed the energy requirements of Part L 2013 by more than 25%.

Arup was also the project's sustainability consultant, and driving down the building's energy demand was central to achieving a Breeam Excellent rating. The consultancy ensured all office spaces in the building were able to operate without mechanical cooling.

Creating flexible spaces

The building is designed to respond to the changing needs of Judge Business School, which comprises teaching spaces, as well as open-plan and cellular office space. There is also a commercial kitchen and dining area for 200 people. Such multifunctional spaces are an increasing trend; the way in which we use a building can - and should - change over its lifetime.

One advantage of the distributed ventilation system in use at the Simon



Winter operation Ventilation units integrated into the façade provide ventilation and heating on demand VOC sensor used to regulate air quality

Simon Sainsbury Centre: Distributed, mixed-mode ventilation strategy

Arup designed a building that is capable of being ventilated mechanically or naturally



"Multifunctional spaces are an increasing trend; the way we use a building should change over its lifetime"



Sainsbury Centre is that layouts can be changed with relative ease; cellular spaces can be repurposed to create an open-plan office, and the larger floorplates can be subdivided. Arup has been able to offer the client guidance on the opportunities of space flexibility, allowing the building to adapt in the future.

By employing an innovative approach to building services, Arup satisfied the multifaceted requirements of this project, despite new challenges emerging in an industry facing stringent regulations.

Its building services design not only preserved the centre's dramatic and clean aesthetic, but went one step further to exploit the thermal mass of its structure and create an environment that optimises comfort, remains flexible, and uses significantly less energy than a traditional system.

Joshua Bird is a senior engineer at Arup

Drawing fresh conclusions on classroom ventilation

Temperature and air quality in classrooms are known to affect learning, but new schools are often built on tight budgets and with low carbon ambitions. Post-occupancy evaluation is adding to the evidence for local hybrid ventilation systems, says BAM Construct UK's **Paula Morgenstern**

he latest BB101 update encourages the use of mixedmode ventilation to achieve a compromise between internal conditions, fuel bills and construction costs in schools. While hybrid systems come in many different configurations, natural ventilation with local mechanical recirculation of the incoming air is one common option where local conditions do not dictate otherwise.

Since 2015, BAM Construct UK has installed local recirculation units by Breathing Buildings, Monodraught, Gilberts and other manufacturers on approximately two-thirds of its schools projects. This figure is likely to be the same for other design and build contractors.

Contractor-led post-occupancy evaluation (POE) was undertaken in four recently completed new-build – and one refurbished Large windows retained sufficient daylight within the classrooms



- school. Three of the schools use local recirculation units in classrooms, while the teaching spaces in one are fully mechanically ventilated, and – in the last – fully naturally ventilated.

The POEs used a range of methods, including: project team interviews; occupant surveys; and a technical walk-around that encompassed a review of building management systems and the analysis of energy data. This article draws out highlights and adds a

construction perspective to a debate that is often dominated by design considerations.

The POEs revealed that teachers generally express satisfaction with the indoor environmental conditions in their classrooms, albeit more so in winter than in summer. Analysis of energy use found that electricity intensities were in line with expectations – lowest in the naturally ventilated school and highest in the mechanically ventilated one, with mixed-mode schools sitting in between.

Where façade ventilators were installed in single-sided arrangements, occupants noted that the classrooms could feel very warm and

stuffy during the summer. In contrast, in the two schools where cross-ventilation was enabled – via roof terminals or automated roof lights in the atrium – there were higher levels of satisfaction with comfort and, particularly, with perceived air quality during warmer months.

After the technical walk-arounds, ventilation unit controls were recommissioned where required, to improve conditions. Teachers were also retrained in the use of the boost buttons, because it was clear from questionnaires and conversations that many of them did not understand how the hybrid ventilation units worked.

Overall, construction team feedback on local recirculation units for hybrid ventilation was positive. Project teams had worked with units from different manufacturers and their quality was found to be comparable, so procurement decisions are largely made on cost grounds.

Unit dimensions – 300mm (H) x 1,000mm to 1,200mm (D) x 900mm (W) – are fairly substantial, so the fact that units will be visible in the classrooms needs to be considered during design development. In the case study projects, some users had different expectations about how things would look in classrooms.

There were few buildability concerns with the hybrid ventilation units. For refurbishments, low floor-to-ceiling heights and narrow ceiling voids have been highlighted as considerations in relation to unit sizes. To maximise room heights in the refurbishment case study, classroom ceilings were only lowered in the part of the room where the hybrid ventilation unit was installed. In rooms where several units were required to meet higher ventilation requirements – for example, a dance studio – the entire ceiling was lowered.

Both solutions looked fine, aesthetically, and retained sufficient daylight because of the large windows, while highlighting the flexibility and practicality of local recirculation units for refurbishment projects. Overall, the analysis adds to the growing body of evidence that hybrid ventilation based on local air recirculation is an effective solution to achieve acceptable comfort conditions in general classrooms, while offering value for money.

There is, in particular, a potential for the use of façade ventilators in refurbishment projects, to improve indoor air quality without requiring excessive changes to the existing services provision – for example duct- and pipework, existing BMS set-up, and so on. It was also highlighted that local recirculation units can have operational "The analysis adds to the evidence that hybrid ventilation based on local air recirculation is an effective solution to achieve acceptable comfort conditions in general classrooms, while offering value for money"





The hybrid ventilation units will be visible in classrooms, so their size needs to be considered at the design stage; automated roof lights enabled cross-ventilation

benefits by reducing system complexity and maintenance requirements compared with full mechanical ventilation. This is particularly relevant for small or stand-alone schools that operate on limited operational budgets and may not benefit from specialist facilities management (FM) support.

Hybrid classroom ventilation has its limitations, however. Especially where ventilation is single-sided, there can be concerns about perceived air quality and, in particular, thermal comfort levels during summer. These findings will partly relate to the expectations of the occupants, who may find the permissible design temperatures of 28°C too warm in which to work and study, and increasingly demand air conditioning.

At the same time, cross-ventilation can support thermal comfort during hot periods where the design provides for it. Of the Education and Skills Funding Agency's (ESFA's) standard designs for new schools, the so-called 'superblocks' may offer this advantage because of the inclusion of ventilation stacks.

Manufacturers of hybrid ventilation units are working to address further overheating concerns. Local recirculation units may be combined with a ground or air source heat pump to add pre-heating or cooling to the incoming air. Alternatively, phase change materials can be added to the recirculation units as thermal batteries, capable of buffering temperature peaks by storing the heat introduced by 30 students during two to three hours (thermal energy storage 6-10kWh depending on quantities of modules).

Further performance evaluation studies will be required to assess the contribution of these new technologies, while their cost is currently still too high for ESFA schools.

Within BAM Construct UK, the data from post-occupancy studies will be used to improve specifications, buildability and performance of future projects.

- **DR PAULA MORGENSTERN** is building performance manager at BAM Construct UK
- This article is based on a paper that will be given at the 2018 CIBSE Technical Symposium, at London South Bank University from 12-13 April. Book at **www.cibse.org/symposium**

Know your limits

Whatever the ventilation strategy in schools, designers must meet noise limits set out in BB93 Acoustic design of schools - performance standards. **Breathing Buildings** explains

> Sound is caused by vibrations in the air. The loudness of a sound is determined by the amplitude of these vibrations.

Sound power is the energy emitted by a source each second.

Sound pressure is the difference between the pressure generated by a sound wave and the static air pressure.

So...

sound power is what acousticians use to compare the noise generated by different sources...

But... sound pressure is what a listener experiences.

BB93

Normal classroom

Normal teaching activity

- Mechanically generated system noise ≤ 35 dB
- Total room noise (including external break-in) ≤ 40 dB

Hottest 200 hours*

- Mechanically generated system noise ≤ 40 dB
- Total room noise (including external break-in) ≤ 40 dB

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External break-in noise



Different sources

BB93 (updated December 2014) sets limits for the indoor ambient noise level (IANL), which is a measure of room sound pressure.

IANL does not include noise generated from classroom activities and equipment, such as speech, projector, computers and so on.



- Mechanically generated system noise ≤ 45 dB
- Total room noise (including external break-in) ≤ 55 dB

* Must be under local control of the teacher

For refurbishments of existing buildings, most spaces are allowed a relaxation +5 dB on any of the above values.

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- Berg

"UF has standardised UV lights downstream of cooling coils to prevent microbial growth on wet surfaces"

atherly Hall, built in 1953, is part of the University of Florida (UF) Campus Historic District, which is included on the National Register of Historic Places. California-based Affiliated Engineers was appointed to renovate 31,000ft² of this four-storey, 61,000ft² building, including classrooms, computer labs, and faculty offices associated with UF's

Warrington College of Business Administration. The design team completed a comprehensive planning study to replace the HVAC system, then aligned the project scope with UF's budget and priorities to implement the first phase of a two-phase HVAC replacement.

The aim was to improve reliability and indoor environmental quality (IEQ), and to offset the additional heating and cooling energy associated with the increased outside air quantity with other energy efficient improvements. Completed on time and under budget, without any disruption to the occupied upper floors, the project resulted in improved energy efficiency, better indoor environment, easier operations and maintenance (O&M), and modernised learning spaces.

Energy efficiency

The first step was to perform a comprehensive facility assessment and planning study that surpassed Level 1 Audit requirements, as defined by ASHRAE Standard 100-2006 – Energy Conservation in Existing Buildings. In spring 2014, the team developed a baseline for the building's energy, O&M, and IEQ, in cooperation with UF's Physical Plant Department (PPD) and Department of Planning, Design and Construction (PD&C), as well as various subconsultants and vendors.

The assessment included workshops with PPD and PD&C to develop a list of initial recommendations. Basis of design (BOD) narratives and conceptual drawings were then developed to describe the viable options, establish cost estimates and prioritise tasks. The study yielded a design-phase project scope, including:

- Replacement of two dual-deck constant volume air handling units and general exhaust fans
- New unlined ductwork, variable air volume units with terminal hot-water reheat
- Replacement of chilled and heating hot-water pumps and piping distribution
- Migration from pneumatic to electronic building automation system (BAS)
- Incidental ceiling replacement, painting, and electrical wiring to support HVAC scope.



Bonus savings account

Affiliated Engineers' **Melody Wang** outlines how a project to replace end-of-life HVAC equipment in an American college became a chance to introduce energy-saving strategies into a historic campus landmark



To maximise ceiling heights. supply air terminals and main ducts had to be above the central corridor ceiling



instrumentation to vary fan, pump, and coil outputs in response to loads within the building. The project took advantage of the upgrades to implement optimum start functions and to reset sequences for temperature and pressure.

Building analysis software was used to model heating and cooling loads for each of the new systems compared with the existing installed capacity and thermal comfort reports from the assessment phase. Envelope documentation was not available, but the team developed approximations for envelope and glazing performance, based on historical data and the architectural portion of the facility assessment. For example, the analysis used representative models of the glazing to account for the percentage of windows that were cracked and/or had failed seals. This revealed that the capacity of the installed equipment fell short of the new required capacity by only 2-4%.

After completion of the project in August 2015, the site energy use intensity (EUI) was 476 kWh·m⁻² per year, based on data provided by PPD. An EUI improvement of 20-30% was achieved without any work to improve the building envelope, and is within 16% of the national median reference value of 410 kWh·m⁻² per year, as reported by the Energy Star portfolio manager for college/university academic buildings.

UF is now in the second phase of renovations, which will further improve EUI, and use more detailed monthly energy-use comparisons, by utility type, to isolate deficiencies, tune building automation system (BAS) control algorithms, and monitor patterns to identify new energy-conservation opportunities. As part of the campus energy management programme, PPD follows a detailed preventative maintenance scheme to manage tasks such as filter replacements and fan service.

Indoor environmental quality

In the 'as found' condition, maintenance access for the existing outdoor air (OA) preconditioning units was severely limited. There was no direct control or measurement of OA flow, so there was no means of protecting the chilled water coil from freezing during the winter. At this time of the year, the inlets of the OA units were usually blocked off to protect the chilled water coils, thereby cutting off the OA ventilation to keep coil tubes from bursting.

The systems implemented for this renovation were designed for OA flow rates calculated using ASHRAE Standard 62.1-2013 Ventilation for Acceptable Indoor Air Quality with required modifications for sufficiently positive building pressurisation. These calculations followed the ventilation-rate procedure described in the standard, using a zone ventilation effectiveness (Ez) value of 0.8 to represent ceiling supply of warm air during heating mode, which was considered the worst-case condition in terms of ventilation. Because each of the new systems had multiple variable-volume zones, the design used the alternative procedure for calculating system ventilation efficiency (Ev) in lieu of the values in Table 6.3 of the standard. UF promotes general standard indoor design conditions of 24.4°C dry-bulb temperature during cooling mode and 22.2°C during heating mode, and humidity limits of 30% RH to 60% RH. These conditions have been confirmed with Chapter 22 of the 2012 ASHRAE Handbook - Systems and Equipment,

Standard 55-2013 and the ASHRAE Thermal Comfort Tool.

Chapter 22 indicates that humidity below 40% RH may result in electrostatic discharges, but this does not occur in the humid Gainesville climate. The metabolic rate used for the calculation is 1.1 met and the clothing level is 0.57 clo, to represent typical summer clothing. A commissioning authority verified systems were installed, calibrated and operating in accordance with the owner's project requirements, BOD narrative, and construction documents.

The new supply air terminals and main ducts had to be above the central corridor ceiling, to maximise ceiling heights in the classrooms while giving clear access to air terminal controllers and piping devices for reheat coils. This required an innovative approach to duct and pipe routing, in detailed 3D coordination with electrical and IT designs using BIM to maintain ceiling heights. As part of the building's electronic control system retrofit, this project set the stage for a future swap-over of the heating hot-water system from constant-volume pumping to variable-flow operation. The first phase installed a new variable speed hotwater pump and DDC components to allow for variable-speed pump operation.

Maintenance and operation

In the 'as-found' condition, each mechanical room and the adjacent above-ceiling spaces were filled with equipment and distribution, as originally designed. This configuration allowed little or no access for PPD to maintain components. The existing air handling units (AHUs) used single, beltdriven fans that were too small to allow access for periodic maintenance. The new units were designed with clear aisles adjacent to the equipment, access doors between each component, and windows in access doors for fan sections, to allow for visual inspections and service. Units were also designed with direct-drive multiple fan arrays with 42kW premium efficiency fan motors, to give a level of redundancy and to streamline fan-motor replacement in terms of motor handling and standard motor sizes.

Lighting and receptacle circuits were powered through separate breakers, to maintain lighting in the event of a tripped breaker associated with a receptacle. UF has standardised UV lights downstream of cooling coils to prevent microbial growth on wet cooling coil surfaces. Ballasts for UV lights were installed on the exterior of the units' casing, making them more accessible for routine maintenance.

Each AHU was painted for corrosion resistance and installed on a raised steel frame. This allows for visual inspections underneath the unit and protects the unit casing in the event of a water leak. Outside air plenums were also given access doors, and there were access doors upstream and downstream of all terminal reheat coils, to allow PPD to observe and clean the coil faces.

Cost-effectiveness

Beginning early in the conceptual planning stages, the design team worked with in-house cost estimators and equipment vendors to develop multiple models to quantify the budget implications of various options for new equipment. This model was used to refine its level of detail at each stage of design and was subsequently compared with the construction manager's cost model. By careful, continuous budget management, the project team avoided the need for late-stage value engineering activities, and supported early decision-making to maximise value.

Matherly Hall has been in full operation since the renovations were concluded, and has undergone detailed post-occupancy commissioning. Its proven performance on occupant comfort, streamlined maintenance, and energy conservation are a result of thoughtful planning, diligent leadership, and careful execution. **CJ**

MELODY WANG is a mechanical engineer and energy analyst at Affiliated Engineers



PRODUCT NEWS

Intelligent multi-sensor lighting system installed at German school

Guided-light feature leads students through the building in a 'pool of light'

Lighting controls manufacturer B.E.G. has installed its new Dalisys system in a German comprehensive school for the first time.

The recently constructed, £10m Blautopf School has a 400m² learning centre, as well as smaller classrooms. Its corridors are occupied for short periods of time, so lighting levels and timings had to be flexible and responsive to the activity in each space.

The Dalisys system can send individual commands, triggered by a user or the environment, to multiple zones simultaneously. It includes a wide range of multi-sensors, including a 'wellness' one for control of light colour in tune with natural daylight. As well as dimming light in unoccupied zones, the system has a 'guided light' feature that leads students through the school in a 'pool of light'.

Luxomat detectors select the optimum level of lighting based on the time of day and availability of natural daylight. To maximise the comfort of each student's workstation, the detectors use regulation algorithms and external light sensors to minimise the effect of reflections from windows.

Award-winning Oastler Building employs Trox AHUs

Trox X-Cube air handling units (AHUs) have been installed at the £28m Oastler Building at the University of Huddersfield. The Breeam Excellent building includes four, 300-seat lecture theatres, tutorial spaces, offices, language labs and a mock court room, plus large, open-plan communal spaces.

Designed by AHR, the striking design and impressive levels of environmental performance secured the building its place in the 2017 Local Authority Building Control Grand Finals, after its win at the regional competition.

The X-Cube's variable-flow control technology allows room-byroom air management, adjusting automatically to requirements. Designed to connect to a centralised BMS, its built-in control technology avoids the need for complex or expensive bespoke

programming of the BMS.

Trox claims the AHUs' control capabilities allow easy integration throughout the air-distribution system, monitoring and controlling dampers, duct sensors, volume-flow controllers and fire dampers with greater precision than using BMS control alone.





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CPD PROGRAMME



Applying solar shading to reduce overheating in buildings

This module explores how appropriate applications of solar shading can substantially reduce solar heat gain, alleviating the need for active cooling interventions

Although intended primarily to reduce heating requirements, the increased use of insulation and the demand for greater building air-tightness have unintentionally combined to produce a growing number of buildings that suffer from 'overheating'. The universal application of double-glazed windows, which are also designed to reduce heat loss in colder seasons, can contribute to the overheating problem during times of moderate, as well as higher, outdoor design temperatures, plus at times of high solar irradiance. This CPD article will consider how appropriate applications of solar shading can substantially cut solar heat gain, alleviating the need for active cooling interventions.

In 2015, the Zero Carbon Hub¹ indicated that 20% of the housing stock suffers from overheating. February 2018's *CIBSE Journal* CPD article discussed some of the potentially serious consequences of overheating that relate particularly to the adverse effects on occupant health and wellbeing. The Committee on Climate Change² notes that 'people lack a basic understanding of the risks to health from indoor high temperatures and are therefore less likely to take measures to safeguard their and their dependents' wellbeing'. Although interest in residential overheating has been popular, the challenges extend across the whole built environment, including commercial and institutional buildings. In 2016, Dr Angie Bone³ of Public Health England highlighted that 90% of existing hospital wards were overheating.

In equatorial, arid and Mediterranean climate zones, building technology has evolved to cope with the risks of overheating. These include the instinctive application of reflective roofs and walls, exterior shades, and low-emissivity window coatings and films to reduce or practically eliminate the adverse impact of solar gain. In temperate regions, such as the UK, the typical historical applications of solar control have principally been to cut problems from disability and discomfort glare, while also allowing the flexibility to benefit from useful solar gain during periods of cooler weather. In the past half-century, as building technology



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(and internationalisation) has enabled lighter-weight, highly glazed structures and – more recently – highly insulated, well-sealed constructions, the application of solar control has often become essential. The westerly facing aspect can suffer most notably, and is the greatest challenge, as the lower solar altitude during the afternoon can produce significant solar gain as the incident angle of the solar radiation (with vertical windows) increases transmission.

As outdoor temperatures rise, as a consequence of climate change, overheating is likely to become more common, so analysis is required at the design phase to ensure that appropriately holistic solar control measures and ventilation can be incorporated into the design. (This is discussed in the recently published CIBSE TM59 Design methodology for the assessment of overheating risk in homes.) The overheating report (as recommended by TM59) must produce dynamic modelling results both with and without blinds, indicating how significant they are in generating a 'pass' result. If blinds are part of the mitigation strategy, they must be allowed for in the model and then installed.

» Determining the performance of solar control measures

The solar gain factor 'g' is used to express the proportion of heat gain into a space resulting from the total solar irradiance incident on the outside surface of the glazing. Practically, this has the same value as solar heat gain coefficient (SHGC), which is more popular in some areas of the world. Neither should be confused with the (formerly popular) shading coefficient, which is derived by comparing the solar heat transmittance properties of any glass with a clear float glass having a total solar heat transmittance of 0.87 (that is, clear float glass about 4mm thick).⁴ The solar gain factor includes the secondary heat transfer from the (warmed) glazing to the inside, so accounting for the heat transfer by convection and long-wave infrared radiation. (There is a more extensive explanation of the transmission properties of glass and glazing systems in Appendix 5.A5 of CIBSE Guide A 2015.)

To account for temporal variations in performance, the total solar energy transmittance, gtot (formerly referred to as 'effective g value'), is more useful in giving a more representative value for the performance of glazing and associated shading systems across the cooling season. In CIBSE TM37, g values and the various correcting factors are tabulated for a range of glass types (such as 'low-e' glass), blinds, louvres, overhangs and shades. It also provides correcting factors for moveable devices, based on the fraction of time that the shading is in place. All the data is related to the surface orientation, and corrections are given for different UK geographical locations. A gtot of 1 would indicate all incident radiation was being transmitted into the space and zero would be for a facade that totally reflected all incoming solar radiation.

The total solar energy transmittance can be calculated for combinations of glass, coatings, shades and blinds (as in the examples in TM37) so that the overall g_{tot} can then be applied to determine the solar gain through the combined system. Solar and optical performance data of shading materials tested to European standards is available from the European Solar Shading Database at **www.es-so-database.com**

Methods of solar control

In a 2012 report on the performance of eight Danish passive houses, Larsen⁵ concluded that 'it is important in the future to introduce the opportunity for active use of natural ventilation combined with external solar

shading in our homes', and again highlighted the importance of incorporation of a proper solar shading and ventilation strategy at the early design stages. Notably, it was highlighted that 'thermal mass has a positive effect only as long as it is possible to cool the structure during the night hours... otherwise thermal mass may instead increase the overheating problems'. A recently completed overheating study⁶ by De Grussa, conducted in homes in Camden, London, indicated that thermal mass (even when combined with an appropriate ventilation regime) does act to adversely affect the occupied space, with the supporting data showing that the monitored rooms were 27°C even at 6am. Without shading, the maximum operative temperature was 47.5°C, but by applying external shading, operative temperatures were reduced by 10.6-17.9K, while with internal shading, these fell by 8.5-12.9K (at 95% confidence levels).

The wide variety of solar control glasses that are available are of two main types: absorbing glasses, which are body tinted; and reflective glasses, which have a specific surface coating. Reflective glasses are usually superior at rejecting incoming solar gain. Absorbing glass heats up more when sunlight falls upon it, and some of this heat can reach the inside of the building. Solar control films (for performance that approaches that of coated glass) can be added onto flat glazing. Although less durable than factory-treated glass, they can be retrofitted onto existing glazing systems.

As with fixed systems, both glazing and solar films will reduce useful winter solar gain and daylight. A US study⁷, undertaken in the 1990s, indicated that occupant satisfaction drops if the light transmittance of the window is less than around 25-38%. Dynamic solar shading could allow for more glazing to be used while maintaining light transmittance.

The most effective way to control overheating is to prevent sunlight from reaching the window, so static or dynamic external shading is particularly appropriate for heavily glazed buildings. Simple static overhangs can be highly effective at blocking high-angle summer sun, particularly on south-facing windows and, if properly fitted, do not obstruct their opening and retain a full view. Problems from lower sun angles can be resolved with dynamic shading devices.



Light shelves (an overhanging element installed part way up a window, typically just above an occupant's head height), allows extra daylight to enter the space by reflection from the top of the shelf, passing through the glazing above it. Having an internal shelf as well as an external one helps control internal glare.

External horizontal slatted and screen roller blinds and other types of external controllable louvres can have the lowest solar gain factor of any system, as well as being able to maintain an outward view by using retractable blinds with occupant, or automatic, control. A more open-weave fabric blind can give a view out even when lowered (dependent on its colour), with glare from the sun controlled by selecting a screen material with a low visible light transmittance.

The solar performance of a mid-pane blind (located in between the two layers of glass) will be between that of an external and an internal system. Mid-pane blinds can be controlled from the inside of the building or through automatic control.

When implementing any mid-pane or external shading, maintenance and access for window cleaning should be carefully planned.

Internal systems (such as roller blinds or louvres) can contribute towards solar heat control but tend to be less effective than external or mid-pane installations. The incoming solar gain will be absorbed by the shading device, and then part of the heat is convected or re-radiated into the interior space. A reflective coating on the outward face of the blind will reflect some of the solar radiation, usually transmitting less heat into the occupied space. Semi-opaque materials are available that control the solar gain while still allowing some daylight. Whatever the type of moveable blind, occupants must be properly educated in how to deploy them for best overall effect, so avoiding unwanted operational effects (such as excessive use of artificial lighting when daylighting could usefully be employed).

For new constructions and extensive renovations that include the replacement of the glazing (or where there are issues from external noise), a double-skin façade incorporating shading can offer an efficient option that effectively has an external shading system but which also benefits from the natural ventilation created within the façade.

CIBSE TM37 *Design for improved solar shading control* provides detailed guidance on the generic types of solar control methods summarised in this article.

The estimable and accessible guidance *BRE 364 – Solar Shading of Buildings*⁸ (and associated information papers) have recently been updated. As well as including a commentary on the credits that shading can contribute to environmental ratings, it provides a useful tabular summary of performance data for different shading systems. The table includes several parameters. However, in terms of 'summer solar control', external and mid-pane measures are clearly most likely to offer a suitable solution. (This does not exclude the need for a thorough life-cycle analysis, but it is a very useful starting point.) It notes that of the devices in the table, 'only sophisticated external blinds systems are really effective at controlling both solar gain and sun glare.

Where both heat and glare are important, a hybrid approach is often best, perhaps with a *brise-soleil*, awning or window film to control summer heat, and internal blinds for glare'. Once again, the BRE guidance confirms the importance of solar shading being included at the design stage.

Some notable examples of applying solar control

The 2016 report⁹ by the National Energy Foundation (NEF) includes several independent case studies and analysis of the current and potential impact of solar shading in the UK built environment. As well as providing detailed information that is not necessarily in the other materials referenced in this article, it includes a study of the Shard, London (Figure 1), which is summarised here. The Shard has triple-skin glazing, with motorised open-weave roller blinds and a ventilated cavity between the inner and outer layers of glazing, as illustrated in Figure 2. The blinds are automatically controlled by a system that tracks the angle of the sun and solar gain throughout the year. The total solar energy transmittance of the double-skinned façade is approximately 0.12, and without dynamic solar shading the building could not have been built. The Shard is estimated to have equivalent annual CO₂ emissions of 28.2kg·m⁻², which would be around a third of the average (75kg·m⁻²) of the 50 new construction non-domestic buildings studied as part



Figure 2: Sketch of the Shard's ventilated and shaded façade (Source: BBSA)

of Innovate UK's Building Performance Evaluation portfolio.

Using blinds to reduce the solar gain means that glass can be more transparent (low-iron glass), improving daylighting and making the building lighter. The controls are designed to lower blinds when solar irradiance reaches 200W·m⁻² (but can be adjusted if required).

The England Building Regulations Approved Document L2A requires a maximum g_{tot} of 0.68 in summer – the Shard achieves 0.12.

For new UK buildings, where most blinds and shutters are within the Fixtures and Fitting (N10) section of RIBA's National Building Specification (NBS), this can conspire to remove the correct integration of solar shading within the facade design. Solar shading should be considered at the design stage, and would potentially have more impact on the holistic energy assessment if it was part of the building services design responsibility. Since it is estimated that 80% of existing buildings will still be standing in 2050, there is also great scope for the adaptation of single and uncoated double-glazing systems in the building stock where there are issues with overheating, or simply to meet the imperative to reduce cooling loads, air conditioning costs and environmental impact.

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Turn to page 22 for further reading and references. \gg



[»] Module 125

April 2018

- In 2015, what percentage of the housing stock was identified as being overheated?
- 🗆 A 5%
- 🗆 B 10%
- □ C 15%
- □ D 20%
- 🗆 E 25%
- 2. Which CIBSE Technical Memorandum considers the required design methodology for assessing overheating in homes?
- □ A TM13
- □ B TM37
- □ C TM52
- □ D TM54
- 🗆 E TM59
- 3. In the studies of homes in Camden, what reduction in operative temperature was suggested as being caused by internal blinds?
- 🗌 A 8.5-12.9K
- □ B 8.5-17.9K
- □ C 10.6-12.9K
- D 10.6-17.9K
- 🗆 E 12.9-17.9K
- 4. What is the approximate total solar energy transmittance for 4mm clear float glass?
- 🗆 A 1
- 🗆 B 0.87
- 🗆 C 0.67
- 🗆 D 0.47
- 🗆 E 0.27
- 5. What is the total solar energy transmittance for the double-skinned façade with motorised open-weave roller blinds, as described in the article?
- 🗆 A 0.08
- □ B 0.12
- □ C 0.16
- 🗆 D 0.20
- 🗆 E 0.24

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Further reading:

CIBSE TM37 Design for improved solar shading control 2006. BRE 364 Solar Shading of Buildings - a very readable guide - updated in 2018. For a complete description of glass factors, see BS EN 410:2011 Glass in building. Determination of luminous and solar characteristics of glazing. The Society of Façade Engineering is the CIBSE society with a particular interest in solar control - www.cibse.org/Society-of-Facade-Engineering-SFE.

References:

- Overheating in Homes The Big Picture, Zero Carbon Hub, 2015.
- 2 UK Climate Change Risk Assessment 2017 Synthesis Report: Priorities for the next five years, UKCCC, 2016.
- 3 Presentation to the Good Homes Alliance, 25 November 2016.
- 4 BS EN 410:2011 Glass in building. Determination of luminous and solar characteristics of glazing.
- 5 Larsen, TS et al, The Comfort Houses: Measurements and Analysis of the Indoor Environment and Energy Consumption in 8 Passive Houses 2008-2011, Department of Civil Engineering, Aalborg University, DCE Technical Reports, No. 145, 2012.
- 6 De Grussa ,Z et al, A Case Study assessing the impact of Shading Systems combined with Night-Time Ventilation strategies on Overheating within a Residential Property, 38th AIVC - 6th TightVent & 4th Venticool Conference, Nottingham, 2017.
- 7 Boyce, P et al, Minimum acceptable transmittance of glazing, LR&T 27(3), 1995.
- 8 Littlefair, P, BRE 364: Solar Shading of Buildings, BRE, 2018.
- 9 Seguro, F, Solar Shading Impact, NEF on behalf of BBSA, 2016.



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