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Raising Standards

A+

CIBSE offers important lessons in new design guide for schools

SCHOOL INSPECTION
Post-occupancy study sheds light on classroom performance

ACADEMY OF EXCELLENCE
How a school refurbishment project in Essex scooped a coveted CIBSE Award

SCHOOL AND EDUCATION
SPECIAL

Hard work begins

An Ofsted rating scheme for school building performance would make grim reading. It's not uncommon to see schools ranked Outstanding for teaching but, if the results of the Innovate UK Building Performance Evaluation programme are anything to go by, there would be few education buildings with the same grade for energy efficiency and performance. A number of post-occupancy evalutions (POEs) were carried out in the programme, including one published in a new CIBSE guide (page 12) that is intended to transform the way we build and operate schools.

TM57 Integrated Schools Design focuses on performance in use, and on page 10 Dejan Mumovic explains how the technical memorandum (TM) can lead to more informed clients and a better understanding of the factors relating to the design process.

One school with proven performance is Westborough Academy, the winner of the Refurbishment Project of the Year at the 2015 CIBSE Building Performance Awards. The successful integration of photovoltaics and biomass boilers has resulted in a 30% reduction in carbon emissions and it performs 17% better than a typical primary school. Part of the success was down to the phasing of the scheme, which enabled the project team to apply lessons learned on insulation detailing and services onto the next stage.

Soft landings were key. Detailed training for designers, contractors and staff covered biomass installation and controls and the school was given support post-completion. This is vital for continued performance and something strongly encouraged in TM57.

Alex Smith, editor
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We must adopt a 'can-do' attitude

It is now five years since the Building Schools for the Future programme was abruptly cancelled.

Many have argued that it was a very expensive way to rebuild every high school in the UK. In essence, PFI was off-balance sheet accounting and was certainly not good for the taxpayer long term, but at least the programme offered ideal learning facilities and conditions.

Today, we have the Priority School Building Programme (PSBP). Its aim is to rebuild or refurbish at least one block for each selected school. PSBP1 had 261 schools, of which 14 new builds are now completed. PSBP2 was announced in February this year with 277 schools on the list.

When recently polled, 35% of 1,000 head teachers felt that their schools were unfit for purpose. Examples given were: teaching areas with no electricity because of water ingress; concrete falling from crumbling walls; and classrooms unusable because of the presence of asbestos.

Let us hope that whatever government we have by the end of May focuses on education in terms of investment to raise standards, as opposed to the current slow pace under the PSBP scheme that only focuses on cost.

Our young people need positive surroundings to encourage learning, so the physical environment they are in makes a statement of commitment to them and to the future of our country.

Christopher Dearden
managing director
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Supplement

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Westborough Academy, in Essex, won the Refurbishment Project of the Year at the recent CIBSE Building Performance Awards. **Andrew Brister** looks at how OR Consulting Engineers collaborated with the architect to upgrade facilities at the Edwardian school, and picks out the key lessons learned

CIBSE BUILDING PERFORMANCE AWARDS 2015

WINNER

The Awards judging panel consists of individuals whose combined skills and knowledge span all the elements that impact upon the performance of a building. If you are interested in getting involved then we'd like to hear from you. Applications close 5 May 2015. For more information visit **www.cibse.org/judging**

A LESSON IN REFURBIS

The glory days of the Building Schools for the Future programme may be over, but there is still plenty of work in the sector for building services specialists. With capital expenditure squeezed, the emphasis in the coalition's Priority School Building Programme is now on improvement of existing facilities. A recent phased renovation of the Edwardian school buildings of Westborough Academy, in Westcliff-on-Sea, Essex, offers a template for the many similar structures up and down the country.

Westborough picked up the accolade for Refurbishment Project of the Year (up to £5m) at the recent CIBSE Building Performance Awards – a proud moment for building services firm OR Consulting Engineers. 'It was a privilege to work on the project,' says managing director, Peter Roberts. 'With recent funding cuts to school capital programmes, refurbishment and redevelopment projects will be increasingly important methods of improving school environments with lower budgets – but they also provide an excellent opportunity to add value to existing buildings and save the energy required to demolish and rebuild new schools.'

Westborough Primary School is a three-form-entry primary school and nursery. The original Edwardian facilities have been added to – and extended – over the years, with new playgrounds and classroom blocks, as well as the award-winning Cardboard Building. However, the older building stock and its building services were nearing the end of their useful life, so the school looked for a refurbishment that would reflect its sustainable ethos. With a rising birth rate in the area, the improved facilities would also allow for an increased pupil intake.

Enter Cottrell and Vermeulen Architects – the partnership has worked with the school since 1992 on a number of infrastructure projects – and OR Consulting Engineers. The result is what the team has dubbed the 'Zero Carbon Masterplan Refurbishment' scheme – a three-phased approach to realising a low carbon refurbishment of the existing Edwardian structures. 'What's interesting is that there has been a masterplan for the overall scheme, with more phases coming on stream as more money becomes available,' says Roberts. 'Too often, school refurbishments are done piecemeal, with isolated packages of work and nothing to knit them together.'

The original masterplan goes back to 2009 and was due to be completed in April 2013 as funding was obtained over time. The Phase 1 works (£1.3m) were funded by the Zero Carbon Task Force of the then Department for Children, Schools and Families (DCSF, now the Department for Education), Southend Local Education Authority (LEA) and Balfour Beatty, and were completed in March 2011. The

HMENT

Phase 2 works (£1.2m) were funded by the Academies Capital Maintenance Fund and Southend LEA, and completed in May 2012. The final stage of the masterplan project (Phase 3) was completed in April 2013.

The DCSF was keen to use the school as an exemplar of how older buildings can be refurbished with a low energy agenda, to meet the demands of contemporary education. 'The masterplan project provided a test bed for ways of refurbishing older school buildings in a sustainable manner and a model for future schemes,' says Roberts. 'The project delivers information on the effectiveness of carbon-reduction strategies that can be applied to typical existing primary school buildings.'

Phase 1 of the masterplan resulted in the introduction of renewable technologies (biomass and solar photovoltaics) as part of a Lean, Mean and Green strategy (see box); the upgrade of the fabric in certain blocks; and the creation of a multi-use hall that could be made into one large space or subdivided into seven smaller areas using folding, acoustic partitions.

As further blocks were refurbished in Phases 2 and 3, the extension of the low carbon heating system increased the base load of the biomass boiler and optimised running hours. In addition, water-management strategies – such as rainwater recycling and water-efficient sanitary fittings – were used to reduce water consumption.

The issue of accommodating renewables in a dense, urban area, with housing on all sides, needed careful consideration. 'Reducing carbon emissions to zero through refurbishment of an existing building, based solely on improvements to building fabric and services, has been shown to be difficult,' says Roberts.

'To further improve sustainability, renewable sources of energy are essential. Depending on the context of the project

LEAN, MEAN AND GREEN

The carbon-reduction strategy at Westborough is based on the adoption of 'Lean, Mean and Green' measures.

- **The 'Lean' strategy reduced energy demands, improving the existing building fabric by internally lining walls and roofs with thermal and acoustic insulation, refurbishing windows and improving building air-tightness.**
- **The 'Mean' strategy produced savings through the introduction of: energy efficient lighting; lighting controls; heat-recovery ventilation; power-factor correction; voltage correction; sub-metering; condensing boilers to supply supplementary heating to the biomass system; and new controls for the building services.**
- **The 'Green' strategy introduced renewable energy systems to the project, namely biomass heating and photovoltaic panels.**

there are limits on which technologies can be used. In this case, our original planning application included a wind turbine on the site, which proved to be untenable following opposition from local residents.'

Photovoltaic panels have been neatly integrated on a walkway that the children use to travel between classrooms. The Lean and Mean measures reduced the electrical load of the school by 30%. The 400m^2 of PV panels installed can supply 70% of the demand, leading to a carbon reduction estimated at 17,000kgCO_2 per annum.

A biomass boiler has been included as the primary heat source for the school, with wood pellets chosen as the fuel. Wood pellets have a high calorific value – approximately 3,000kWh/m^3 – so the store size could be reduced compared with what would be needed for a wood-chip boiler. Based on a two-week supply during peak heating season, approximately 3m^3 of storage space – excluding access area – is required. This could be accommodated in an old toilet area. Gas boiler backup allows flexibility in supply.

The 45kW biomass boiler is sized to meet one-third of the peak load. Because of the low carbon factor of localised biomass boiler systems (0.025kgCO_2/kWh), the biomass system is estimated to save two-thirds of the annual heating carbon emissions, which equates to approximately 17,000kgCO_2 per annum. The biomass system is enthusiastically looked after by one of the teachers – testament to the effort put in up front to make sure the school understands how its new facilities are meant to operate (see Soft landings panel, overleaf).

Performance feedback

After completion of Phase 1, Buro Happold's Alternative Technology and Sustainability Unit was brought in to assess the building's performance, and reported a 30% reduction in carbon emissions. In terms of energy consumption, the refurbished areas of the Edwardian school perform 17% better than a typical primary school, based on ECON 73 benchmarks.

Critics will point to long payback periods – in excess of 30 years for the biomass boiler and solar PV. 'Generally, the paybacks are uneconomic,' admits Roberts. 'The fabric improvement measures have paybacks in the region of 23 years. In a financial sense, this improvement is not attractive in isolation, but when this maintenance-free measure is considered against the lifespan of a renovated building – which has already served its community for a century – it is a more persuasive proposition.'

The DSCF continued to support the adoption of these technologies regardless of the financial performance, because it wanted to understand:

- How the technologies performed in practice

> The biomass system is enthusiastically looked after by one of the teachers – testament to the effort put in up front to make sure the school understands how its new facilities are meant to operate

School ventilation

Smart control for clever classrooms

By Dr Chris Iddon CEng MCIBSE
Natural Ventilation
Design Manager with SE Controls

Although classroom air quality and carbon dioxide (CO_2) levels are widely regarded as key factors affecting pupil learning ability, supported by several UK and international studies, the recent findings from The University of Salford's 'Clever Classrooms' research into primary schools, once again underlines the importance of the indoor environment 'naturalness' on students' academic performance.

Ventilation is firmly on the educational buildings agenda as the Priority Schools Building Programme (PSBP), building regulations and the update to BB101 expected later this year have changed the school building landscape with a stricter regulatory environment, including air tightness, energy efficiency and indoor air quality.

In terms of air quality management, whether the ventilation methodology chosen is purely natural, mechanical or a hybrid mixed mode solution, the key to its overall effectiveness rests largely with the how the indoor environment is monitored and, more importantly, how the system is controlled.

CO_2 not only has a direct effect on learning and the ability to perform tasks, but is also a primary indicator of air quality and is now easily measurable. As comfort levels are also dependent on other factors, such as temperature and humidity, the ability to accurately monitor these variables and link them to the ventilation system enables precise control of air quality while also optimising energy consumption and consequent running costs.

However, as air quality and occupant comfort are intrinsically linked to CO_2 and temperature, the best control solutions not only have to deal with these factors, but also the effects of weather, including external temperature, rain and wind, particularly where energy efficient natural ventilation and hybrid systems are deployed.

Note: A copy of the Clever Classrooms report by the University of Salford, Manchester, can be downloaded from the university's website by following this link:

http://www.salford.ac.uk/cleverclassrooms/1503-Salford-Uni-Report-DIGITAL.pdf

Smart control - Intelligent Dynamic Cooling Threshold optimises occupant comfort

In mid 2012, SE Controls launched the NVLogiQ integrated IAQ monitor, room controller and data logger, which incorporated completely new building ventilation controls algorithm, developed in conjunction with Loughborough University's Civil and Building Engineering department.

With the latest evolution of NVLogiQ, it not only maintains good indoor air quality by controlling ventilation based on room CO_2 levels, but also integrates newly developed intelligent dynamic cooling thresholds to deliver optimal cooling performance – whether by controlling natural ventilation vents or local VAV mechanical dampers.

The dynamic set-points used within the control algorithms are calculated based on short term weather conditions rather than actuation decisions being based solely on conditions at a particular time point. This has enormous benefits by eliminating inappropriate cooling of spaces during the mid-seasons and can improve overheating strategies by lowering the cooling threshold during particularly warm weather. As a result, night purge cooling is optimised even during cool summer mornings.

Simple static controls are useful for modelling but can be problematic in use

In the UK's temperate climate, it is well within our capabilities to design schools that use external air for cooling, which can remove the risk of overheating by implementing appropriately sized vents and airflow strategies.

When demonstrating performance, most commonly used dynamic thermal modelling packages allow the modeller to regulate vent or damper positions based on internal and external air temperature at a particular time point.

Usually the vents are opened to deliver external air when internal air temperature is above 21°C and the external air temperature is above 14°C, which ensures that the vents are open sufficiently long enough during the summer to mitigate overheating risk.

While this is good for proof of principle and demonstrating that the design won't overheat, implementing such a simplistic control algorithm in practice can cause unnecessary over-ventilation, which compromises occupant comfort.

As classroom internal temperatures can easily exceed 21°C due to internal gains during spring and autumn, while external air temperature may be around 14-15°C, a simple control would trigger the ventilation system's 'cooling mode' with vents opening to reduce internal temperatures to 21°C. Due to the higher air flow required for cooling, compared with IAQ ventilation, this scenario can easily result in occupant discomfort due to draughts.

A simplistic solution would be to increase the cooling threshold to prevent such unnecessary cooling, but this is likely to result in overheating during the summer as the cooling strategy would not be implemented early in the day when classrooms are unoccupied and relatively cooler.

Overcoming this scenario by implementing seasonal commissioning using alternative set-points for different seasons is one solution, albeit time consuming, but as periods of hot weather can occur 'out of season' overheating can occur if the cooling threshold cannot adapt.

A better solution is to use the intelligent dynamic cooling thresholds within NVLogiQ, which also enables occupants to retain control by allowing the local offsetting of cooling thresholds for their environment for a set period of time before it reverts back to automatic default setting.

Note: Details and product features for the NVLogiQ room controller can be found by following this link:

http://www.secontrols.com/product-catalogue/controllers/nvlogiq-room-controller/features/

- The educational value of children engaging with the operation and performance of these technologies
- The maintenance burden over the life-cycle of the building
- The robustness of the adoption of some technologies in a primary school environment.

The fact that the refurbishment was split into phases meant that the team was able to learn from the initial phase and improve as the project progressed. 'The later phases were much quicker as we learned about the necessary detailing of the thermal insulation, dry lining and the best routing for services in an Edwardian building,' says Roberts. The collaborative nature of the project has also reaped other rewards: the team was working together on other schools projects, as well as a low carbon Hindu temple in Hertfordshire.

Westborough promises to deliver much-needed feedback on what works and what doesn't as the nation looks to revamp its ageing building stock. Let's hope designers do their homework and follow some of the lessons learned from this award-winning refurbishment.

Soft landings

The design team carried out a series of presentations to the client, teaching staff, local authority and DCSF at key stages of the project. The aim was to inform and define the developing brief, and to begin educating users on how to operate and occupy their new building efficiently.

Towards the end of the project, a soft-landing process was employed by the design team and contractor to communicate the key principles of the design, and the key environmental strategies required for efficient operation. Dedicated training sessions – attended by the design team, contractors and staff – were carried out for the biomass heating installation and controls. The team also offered support to the school post-completion, to ensure a smooth transition into occupation for the client.

'This process has paid real dividends and the school has taken pride in its new buildings,' says Peter Roberts, of OR Consulting Engineers. As well as teacher involvement in running the biomass installation, data from the sub-metering and PV display panel have been used in the teaching of the maths curriculum.

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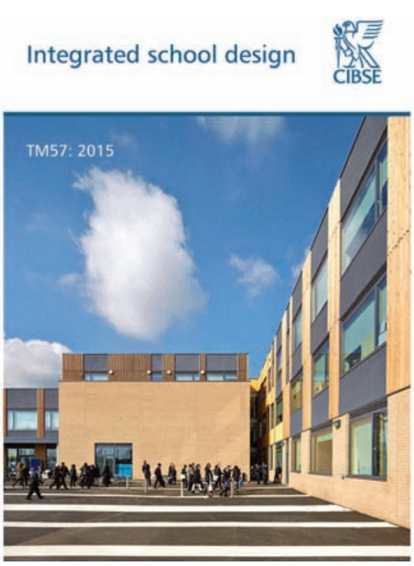
ESSENTIAL READING

CIBSE's guide to integrated school design will be launched at this month's Technical Symposium. Its co-editor **Dejan Mumovic** explains why the guide will help anyone striving to design, construct and operate successful school buildings

TM57 co-author Dejan Mumovic

CIBSE TM57: INTEGRATED SCHOOL DESIGN

- **Launch:** CIBSE Technical Symposium, 16-17 April, UCL **www.cibse.org/symposium**
- Produced by CIBSE School Design Group
- 14 principal authors and 10 contributing authors
- **Editors (and co-authors):** John Palmer, AECOM, and Dejan Mumovic, UCL Institute for Environmental Design and Engineering



Why has CIBSE published a guide to integrated school design?
Spaces for learning are environmentally more complex than most structures. They usually have high heat gains, due to high occupant density and full – or nearly full – occupancy, which is of a transient nature, as pupils come and go; and from lighting, which changes from class to class, depending on the teaching methods used.

Spaces for learning need to perform well acoustically, both for the spoken word and for music – and since sound amplification is generally not used, background noise control is critically important. Carbon and energy targets further contribute to school design challenges.

A key message that this Technical Memorandum (TM) conveys strongly is that school buildings are complex, dynamic, socio-technical systems, seeking to provide solutions to a multitude of ill-defined and conflicting issues. The built environment is fundamental to the pupils' sense of wellbeing, and it is important we understand and appreciate that.

What are the key themes?
The premise behind this publication is the need to focus on the environmental parameters of successful schools, and to identify which design conflicts require the greatest attention. This means looking at acoustic, lighting and ventilation design in the context of energy efficiency and in-use performance.

However, TM57 alone will not guarantee good school design; a checklist of criteria does not constitute successful design. School designers must make the effort to visit existing buildings and study exemplar cases to experience fully the results of the design process, both good and bad. To support this, TM57 also provides chapters on methods for post-occupancy evaluation, and an in-depth integrated case study.

How will the document ensure systems are designed and commissioned correctly?
In this TM, we emphasise that 'performance in use' rather than 'design intention' is the best test of success, and that issues relating to design, building operation, handover procedures and the complexity of BMS systems are found to have a significant impact on outcomes.

To ensure that the systems are designed properly, we have introduced two chapters to the TM: 'Setting the design process' and 'Early engineering considerations and design hierarchy'.

The building services design engineer requires an understanding of the many factors that relate to the design process. This includes an awareness of the various interlocking briefs – such as the masterplan, educational outcomes, capital and revenue costs, and performance-in-use standards – and the roles of the members of the design team.

The potential for building services engineers to foster the role of 'informed client' is clear, because of the wide influence they have over the design outcomes through commissioning, maintenance and operation.

Is there guidance on maintenance and operation?
Yes. The aim in producing this TM is to provide guidance not only for the building services engineer, but also for other members of the design team – such as architects, client bodies and users – who have influence on the design outcomes. By doing this, it is intended that service engineers, in particular, will be able to use their understanding of all aspects of building design and performance to influence a more informed design team.

With this in mind, the section on 'Facilities management' is written to enable the designer to understand the needs of the facilities manager when operating school buildings.

How do we ensure schools are monitored for energy performance?
Part L regulates the energy performance of fixed building services under standardised conditions assumed in the National Calculation Methodology. Unregulated loads, operational conditions – such as occupancy levels, time schedules and temperature set points – that are different from those assumed for Part L calculations, and shortcomings in the commissioning of systems are the main reasons for increased energy consumption.

Unfortunately, in the vast majority of schools, the facilities managers have little or no understanding of energy management. It is the premise of this TM that they must be well equipped to take ownership of energy consumption. We summarised lessons learned from 10 post-occupancy evaluations of mostly secondary school buildings to enable facilities managers to take charge of the day-to-day operation of schools, with special focus on energy management and occupant comfort. The sections on lessons learned are based on substantial research carried out, in the main, by Ian Pegg and Esfand Burman.

Who needs to read *TM57*?
Our hope is that simple and clear guidelines can help steer designers, contractors and users towards creating places where teachers, children and the community can be satisfied – or, dare I say, inspired. TM57 is also essential reading for students of sustainable building design and building engineering physics.

DEJAN MUMOVIC FCIBSE is professor of building performance analysis at the UCL Institute for Environmental Design and Engineering, and co-founder and secretary of the CIBSE School Design Group

ABOUT THE CIBSE SCHOOL DESIGN GROUP

Many of the current CIBSE special interest groups cover specific issues, but the CIBSE School Design Group will integrate design, construction and maintenance issues in a particular sector. The principal terms of reference are to:

- **Foster knowledge exchange between all interested parties working on sustainable school design**
- **Develop a strategy for healthy and sustainable school buildings**
- **Encourage cooperation between professional bodies of relevance to school design**
- **Reflect on changing procurement routes and design standards**
- **Identify gaps in the science of designing learning environments**
- **Initiate cooperation between academia and industry to resolve the problems relevant to the industry**

COULD DO BETTER

Loxford School may have achieved a BREEAM Excellent rating, but a post-occupancy evaluation by **Judit Kimpian** and **Esfand Burman** revealed how value engineering – and a lack of training on operational use of the building – can have a negative impact on actual energy use

KEY FACTS

- **Total floor area:** 14,600m^2
- **Occupants:** 2,000 students, 220-250 full- and part-time teachers
- **Hours:** 08:30 to 15:30 during weekdays
- **Extracurricular activities:** Include night school two days per week, and out-of-hours activities in the drama hall and ground-floor spaces

The Loxford School of Science and Technology replaced an existing secondary school in the London Borough of Redbridge in 2010. The project followed the design and build procurement route, and achieved a BREEAM Excellent rating at design stage.

To compare the design intent with the in-use performance, a post-occupancy study – as part of the Building Performance Evaluation (BPE) programme – was carried out by Innovate UK. A full version of the study appears in CIBSE's *Technical Memorandum 57: Integrated School Design*, including a section on lighting and building-use studies.

The performance gap seen in schools procured under Building Schools for the Future (BSF) was one of the reasons the Education Funding Agency set 'performance in use targets' for the next wave of educational establishments, built under the Priority School Building Programme.

Design intent

Loxford School has two ribbons of three-storey teaching accommodation, stretching from north to south, with two four-storey pods separating the ribbons and forming courtyards. The building consists of a concrete frame with flat-slab construction. The external skin is predominantly precast concrete panels, finished with brick tiles, which meant the building was very airtight. The air-permeability target set at design stage was 5.0 $m^3 \cdot h^{-1}/m^2$ at 50 Pa, which was bettered at completion, with a test result of 4.36 $m^3 \cdot h^{-1}/m^2$. Courtyard-facing façades are clad with a Velfac glass-wall system. East and west façades have perforated vertical louvres to provide solar shading.

After the tender stage, a new headteacher was appointed, so some parameters of the original design and brief were altered to match the incoming head's vision. The project underwent extensive value engineering towards the end, to reduce costs so the design-and-build nature of the contract may have compromised the involvement of the initial designers in building procurement and aftercare, which could explain some of the discrepancies between the design intent and operation, notably in the control settings specified for the natural ventilation strategy.

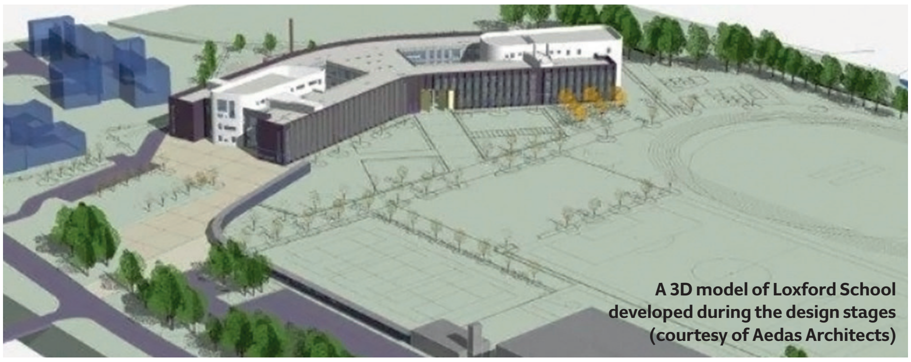
The energy performance of the school was expected to be around 27% better than the benchmark set out by the Greater London Authority, thanks to the adoption of passive design and energy-efficiency measures. Architects and services engineers on the project worked together to achieve an integrated design philosophy in line with these principles, introducing a low carbon technology in the form of ground source heat pumps (GSHPs) to further improve energy performance. Similar to other BSF projects, the client's brief was mainly based on compliance, with design guidelines and regulatory requirements.

Acoustic design

In 2007, the building services engineers conducted an environmental noise survey at the initial stages of the project, to assess the feasibility of a natural ventilation strategy. The measured noise levels and the prediction model confirmed that the façade noise levels would be between 48 and 56 dB LAeq, 30 min. While a natural ventilation strategy was deemed feasible for façade noise levels of less than 58 dB LAeq, 30 min, window openings had to be reduced for façade noise levels greater than 52 dB LAeq, 30 min. Therefore, it was concluded that a single-sided strategy would not be able to provide adequate fresh air. Consequently, a cross-ventilation strategy was developed for the building, to provide adequate fresh air, and to control summertime overheating.

The strategy to control reverberation in classrooms and teaching spaces was based on the use of sound-absorbing material and suspended rafts of acoustic tiles, with light fittings recessed into them. Acoustic tests performed after occupancy confirm that the indoor ambient noise levels (LAeq, 30 min) in general classrooms and science labs are below the Building Bulletin BB93 (DfES, 2003) requirements of 35 and 40 dB respectively. The reverberation times are below the 0.6 second limit prescribed by BB93. Evenly

The school's entrance and (below right) vertical shading



A 3D model of Loxford School developed during the design stages (courtesy of Aedas Architects)

Acoustically absorbing material and suspended acoustic tiles are used to control reverberation

distributed absorbing materials have been used on the ceilings to ensure that a minimum speech transmission index of 0.6 is achieved in open-plan spaces.

Ventilation design

The majority of teaching spaces are naturally ventilated. Cross ventilation is provided by manually-controlled, operable windows on the external façades, and motorised opening vents on the corridor side, which are linked to the classrooms via an acoustic plenum in the corridor. Air quality indicators, with a traffic-light interface, provide feedback about the CO_2 levels in classrooms, prompting teachers to use the operable windows when required. Louvre-mounted operable windows, meanwhile, provide for secure night-time ventilation in summer.

Where cross ventilation into the courtyards is not possible, ventilation shafts are used for stack-driven ventilation. Mechanical ventilation is provided to core spaces that cannot be naturally ventilated, and to a number of ICT-enhanced classrooms.

CO_2 concentrations exceed 1,500ppm at peak times in a typical winter week, but the daily average concentration during teaching hours is often lower than this. However, this depends on how effectively teachers respond to the air quality indicator, operating the windows accordingly. Purge ventilation tests performed on sample classrooms show that occupants can lower CO_2 concentrations to 1,000ppm. The BMS logs and tests performed with portable monitors confirm maximum CO_2 concentration in all classrooms is always well below 5,000ppm, so the Building Bulletin BB101 ventilation requirements are satisfied.

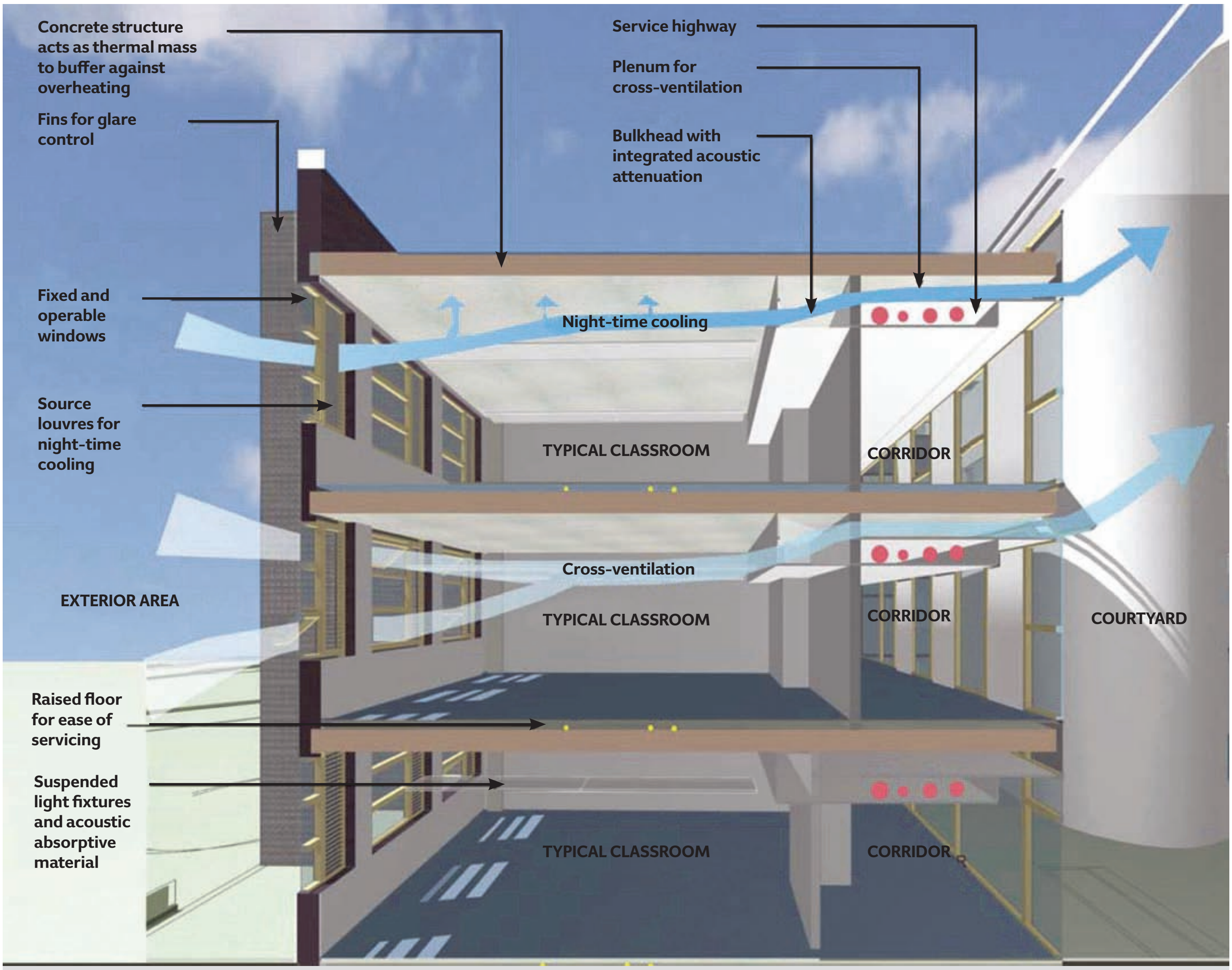
Interviews with staff revealed that while they generally understood the green (ventilation adequate) and red (inadequate) signals from the air quality indicator, they were less sure when faced with the amber colour, indicating excessive ventilation. This mode was introduced by the designers to save energy and avoid cold draughts in winter. Windows should be closed in winter when CO_2 concentrations are low.

Inclusion of simple instructions in the building logbook – and more user-friendly labelling – would make it easier for occupants to understand the system.

Overheating and thermal comfort

The thermal model developed at design stages confirmed that the ventilation strategy satisfies the BB101 overheating criteria when the building is exposed to CIBSE Test Reference Year (TRY) for the closest geographic location.

While the building shows good resilience against summer overheating, recorded data reveals that indoor temperatures could



The cross-ventilation strategy for Loxford School, extracted from the building logbook

exceed 25°C in some parts of the building, in winter and summer. This suggests the main cause for high temperatures is internal heat gain, rather than ambient weather conditions.

Night-time temperatures are generally very close to daytime temperatures. In winter, this is a reflection of a building's airtightness and low heat loss, and suggests there is room to optimise the heating schedule. In summer, it appears that the night-time ventilation strategy is not working as intended, and the louvred windows are not kept open overnight on a regular basis. Following the prescribed night-time ventilation strategy will enhance the summertime thermal performance.

Where internal heat gains are excessive, chilled beams have been installed to provide comfort cooling by direct coupling with the ground loop via a heat exchanger. There is no refrigerant-based cooling source for these spaces. Cooling for the server room and data-hub rooms is provided by variable refrigerant flow (VRF) heat pump systems, operated locally via wall-mounted controllers.

Heating system and controls

The heating is supplied by closed loop vertical ground source heat pumps, installed in an energy centre. It is supplemented by gas-fired condensing boilers. Optimum start/stop control and condensation protection measures have been implemented for the heating system. Heat is emitted using the wall-mounted radiators, radiant heaters, underfloor heating, and air-handling units serving mechanically ventilated spaces.

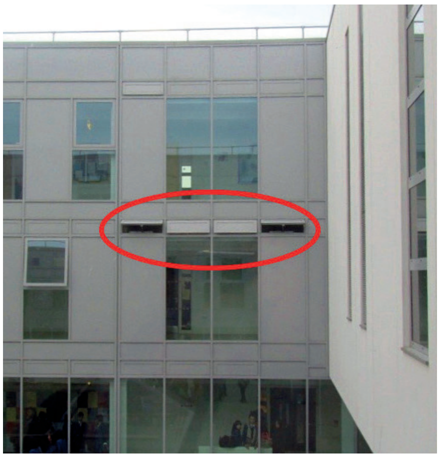
The operation of the GSHPs is limited to ambient external temperatures above 3–4°C, or low-temperature hot-water flow temperatures below 50°C. Under extreme weather conditions – or when higher flow temperatures are required – the GSHPs are disabled and gas-fired boilers take the lead.

In practice, the GSHPs have been disabled much more than expected, even under moderate outdoor temperatures. The malfunctioning motorised vents installed to facilitate cross ventilation led to cold draughts and thermal discomfort in the early stages of occupancy. Lack of training on the proper use of ground-level, corridor door external crash pads also led to the doors being left wide open in winter. Consequently, an adjustment was made to system flow temperatures to ensure that the heating system could cope with the cold draught, and that thermal comfort conditions were maintained (variable temperature slope increased). This could explain why the GSHPs were often disabled and their contribution to heating was less than expected.

Energy performance

The Building Emissions Rate (BER) – calculated for the fixed building services under standard conditions prescribed by the national calculation methodology (NCM) – was 18.5kg CO_2/m^2 per annum. Post-occupancy studies show that the total carbon emissions of the building in 2011, established by the installed metering and energy bills, was 56.7kg CO_2/m^2 per annum, of which 42.7kg CO_2/m^2 per annum was for fixed building services.

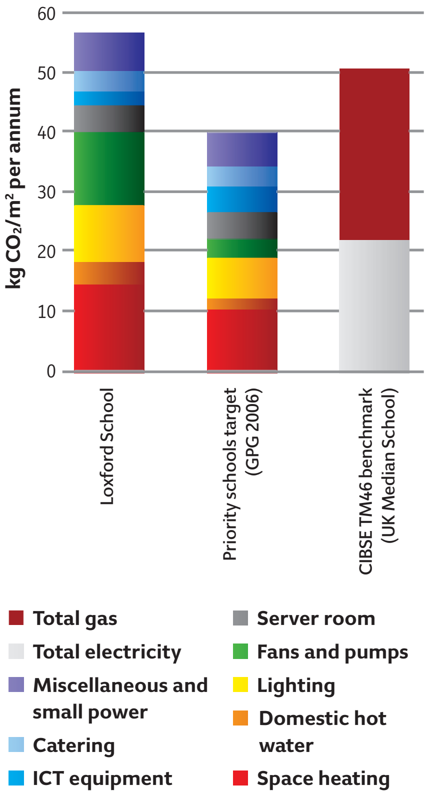
The wall-mounted air quality traffic-light system prompts teachers to operate the windows



A number of motorised vents stuck open in winter, regardless of CO_2 level and temperature

Figure 1 illustrates the total energy performance of the building set against good-practice schools built after 2006 and the median of the national stock represented by the CIBSE TM46 benchmark. It performs worse than both benchmarks. The auxiliary energy consumption related to pump use is especially high. Evidence from the BMS shows that most pumps are working outside normal occupancy hours, leading to a high baseline electrical demand for the energy centre. This may be related to the 24/7 profile set up for the domestic hot-water services and issues with the control regime.

Figure 1: Energy performance



CO_2 conversions factors:
- gas: 0.19 $kgCO_2/kWh$
- electricity: 0.55 $kgCO_2/kWh$

Total energy performance of Loxford School in 2011 compared to benchmarks; the operation targets set out for the Priority School Building Programme are based on post-occupancy evaluations carried out on post-2006 schools so could be used as good-practice benchmarks for Loxford School (EFA, 2012)

Lessons learned

The design process and post-occupancy studies show the integrated nature of school design and procurement. For example, the acoustic studies confirmed the feasibility of natural ventilation (acoustically) where cross ventilation was possible. Yet the actuators specified by the architects for the plenum flaps, initially envisaged to be by the same manufacturer, were replaced by a cheaper alternative from another supplier. Inadequate motor power, as well as poor alignment of the new actuators, led to some flaps being stuck open – resulting in heat loss to corridors and classrooms.

To combat the thermal discomfort caused by these issues, the variable temperature slope was adjusted, causing the hot-water flow temperature to be higher, often, than was required for the operation of ground source heat pumps. Consequently, the gas-fired boilers acted as the lead heating system and the contribution of the GSHPs to the building's heating demand was compromised.

The energy performance data presented for Loxford School is related to the early post-occupancy stages. The BPE provided an opportunity to identify operational issues. Fine-tuning the building based on the findings of this study could lead to a better performance in future.

However, it should be noted that post-occupancy evaluation was not part of the original contract. The building was procured after a standard design-and-build contract, with no requirement to achieve performance targets. A 'Performance in use' brief, outlined in section 2 of *TM57*, enables designers and contractors to work together and fine-tune a building after completion, to ensure performance is optimised and consistent with the design intent.

UDIT KIMPIAN, of AHR-Global, was the principal investigator on the Building Performance Evaluation project
ESFAND BURMAN is a research associate in complex built environment systems, UCL Institute for Environmental Design and Engineering

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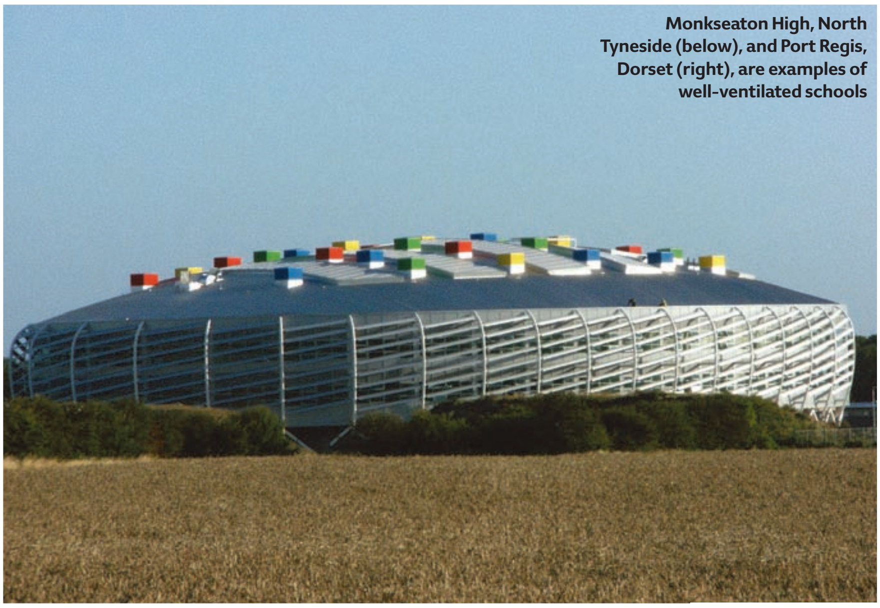


Monkseaton High, North Tyneside (below), and Port Regis, Dorset (right), are examples of well-ventilated schools

TOO COOL FOR SCHOOL

Buildings funded under the Priority Schools Building Programme have to meet new criteria for ventilation and thermal comfort to banish draughty classrooms for good. **Shaun Fitzgerald** explains what this means for designers

The Priority Schools Building Programme (PSBP) was set up as a funding mechanism to ensure schools in the poorest areas of the UK receive financial support for new buildings or refurbishment projects. Educational establishments funded by this programme have to meet a new set of design criteria – the Facilities Output Specification (FOS).

Many schools designed according to Building Bulletin 101 (BB101) suffer from various problems: some are too draughty; some have excessive heating bills; and many are deemed to overheat by occupants.

The new criteria have been devised to tackle these issues, ensuring new buildings are comfortable and energy efficient.

The effort expended by the Education Funding Agency (EFA) in developing the FOS was significant. However, the short timescale for putting the material together meant the document referred to in Building Regulations – BB101 – could not be replaced when the FOS was issued. So, for the past 18 months or so, two documents have been in circulation.

Schools funded by PSBP need to meet both BB101 and the FOS; those not funded by the programme only need to meet BB101. Later this year, new guidelines – derived extensively from the FOS – will be issued as a replacement for BB101, for all schools.

The changes in design requirements for ventilation and thermal comfort can be split into winter and summer. Once a design deals with these extremes, it is likely that internal conditions and energy use during milder days will be fine. It needs to be checked, but, with a good design, it should be straightforward to provide a comfortable space.

Winter design

The drive to reduce energy consumption and the capital cost of school buildings has led, in recent years, to many designers adopting natural ventilation strategies, rather than mechanical systems.

On paper, this seems sensible; the heat gains in most classrooms are sufficiently high that there is little value in a heat-recovery system. In most instances, the value is negative because the additional use of energy required to drive the fans is greater than the saving in heating energy that would have been required with a properly designed natural ventilation system.

However, things have fallen down on the natural ventilation front because many of the systems installed have low-level inlet dampers and an integrated heating element to preheat air, and another high-level vent for outflow. This strategy is more costly than a mechanical ventilation system with heat recovery.

Other natural ventilation systems incorporate just high-level openings. These do not use excessive amounts of heating energy to mitigate cold draughts. However, high-level inflow vents can create unpleasant cold draughts, resulting in dampers being closed, so schools are not properly ventilated.

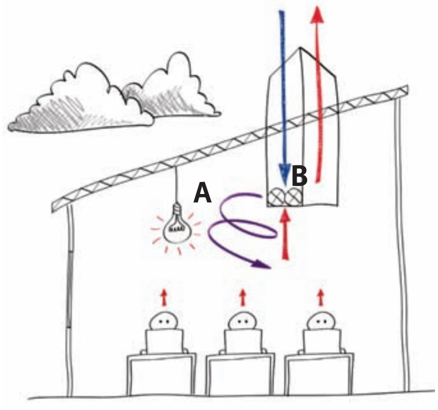


Figure 1: Breathing Buildings' e-stack winter-time mixing strategy
A – Mixed air delivered to classroom no more than 5K cooler than room temperature
B – Fan-assisted mixing of room air with the incoming cold fresh air

Simple, but critical

The regulations state that, if natural ventilation is used, incoming fresh air will have to be mixed with room air before it reaches the occupants, to avoid cold draughts in winter.

The regulations even state the degree of mixing required: the incoming cold fresh air must be mixed with room air until it is within 5K of the ambient temperature in the room, by the time it gets to the lower 1.4m of the space – the seated, occupied zone. The speed of the air hitting someone in this zone in winter must be less than 0.3m/s. In other words, a draught has been defined based on temperature and air speed, and designers need to avoid this (see Figure 1, above).

If there is insufficient vertical separation between occupants' heads and any high-level openings to guarantee adequate natural mixing, then pre-mixing devices can be used.

Summer concerns

There are three significant changes in the way summer overheating is now being treated.

First, the maximum acceptable temperature is now allowed to vary on a day-by-day basis. This is partly because, as a period of hot weather develops, people adapt and are more able to cope with hotter conditions. For example, they are likely to wear looser clothes. The maximum temperature allowable on a given day, therefore, needs to be calculated based on 'the running mean' – the maximum temperatures on each of the previous seven days, with more weighting given to yesterday's temperature than that of the day before.

The next change is the definition of temperature. If people are exposed to cool surfaces, they will feel cooler, even if the air temperature is the same as in another space. Human body temperature is 37°C and people will experience a sense of radiative cooling if the surfaces to which they are exposed are sufficiently colder than their body.

As with any comfort-dependent space, internal temperatures should be defined in terms of 'operative temperature'. This accounts for air temperature plus the mean temperature of the surfaces to which occupants are exposed. Thermal comfort also includes factors such as relative humidity – dry heat is more comfortable than humid conditions – and air speed across people, which can enhance evaporation.

Finally, the weather profile that designers need to use is the Design Summer Year (DSY), not the Test Reference Year, because the DSY is more representative of a hotter year. As well as *TM49 CIBSE Design Summer Years for London*, weather data sets are available for 14 UK locations at **www.cibse.org/knowledge**

The new summertime design criteria are:

1) There must be less than 40 hours a year for which the expected indoor operative temperature exceeds the target daily maximum. An understanding of how often a building in any given location is likely to exceed its comfort range during the summer months (May-September) can provide useful information about the building's thermal characteristics and potential risk of overheating

2) The daily-weighted exceedance must be no more than six. So the number of hours a day that the expected indoor operative temperature is above the daily design maximum, multiplied by the amount above it, must be <=6. This sets a day's acceptable severity level of overheating

3) Indoor operative temperatures shall not exceed 4K above target daily maximum.

To pass the test, two out of these three criteria must be met. However, it is accepted that these summertime design criteria are difficult to measure. So, if a school is thought to be overheating once occupied, the EFA has introduced a fourth criterion – performance in use. The school will be deemed to be overheating if the average internal air temperature exceeds the average external air temperature by more than 5K. This fourth criterion must be met at the design stage.

Conclusions

The new design guidelines should lead to a transformation in the quality of school buildings in the UK. However, they should not exceed the cost of those built in recent years. In fact, there is great pressure on contractors to use standard designs for schools to reduce costs – but the standard design must be right.

Hence the encouragement – not only in the text, but in the way thermal comfort is now defined – of exposed thermal mass and cross-flow ventilation.

The principles of good design are known, and are now required in regulations.

SHAUN FITZGERALD FCIBSE is chief executive of Breathing Buildings

GOING THROUGH A PHASE

Tests in a Nottinghamshire school have shown that adding phase change material to a classroom can significantly improve comfort conditions. **Tony Heslop**, of BASF, explains

The Priority Schools Building Programme (PSBP) – successor to Building Schools for the Future – offers a new approach to that of Building Bulletin 101 (BB101), including the use of exposed thermal mass in classrooms to reduce the risk of overheating.

The presence of exposed thermal mass, such as a concrete surface, allows heat to be absorbed from a space during the day to help keep it cool. This heat is then given out by the thermal mass when it is cooled using night-time ventilation. Another advantage of exposed thermal mass is that, during the day, it will heat up more slowly than a lightweight material. As a result, it has a lower surface temperature, which can provide additional comfort to occupants.

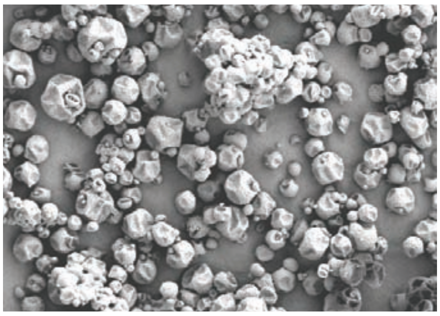
In the past, a room would probably have been built with a large area of exposed concrete or brickwork to enjoy the benefits of thermal mass. Such heavyweight forms of construction can increase time on site and cost more to build than a lightweight structure. A cost-effective alternative is to build a school using lightweight construction techniques and add exposed thermal mass in the form of phase change materials (PCMs).

PCMs absorb far more thermal energy than equivalent conventional material, because they change phase – usually from a solid to liquid and back again – at room temperature. Breathing Buildings worked with Armstrong Ceilings to investigate the impact of retrofitting thermal mass in the form of PCMs to a classroom at Belvoir High School, Bottesford, Nottinghamshire.

The school, built in 2009 to comply with BB101, is a lightweight construction. Two identical, 58m², first-floor classrooms were selected for the test. Each had through-the-roof ventilation units installed. These were sized to meet summertime overheating requirements and minimum daily average ventilation demands, to limit room CO_2 levels. Each room had opening windows and a conventional suspended ceiling, formed from 600x600mm ceiling tiles supported on a metal grid.

In one of the classrooms, half the conventional ceiling tiles were replaced by tiles with integral PCM to test the impact of additional thermal mass on room conditions. The tiles covered an area of approximately 20m².

The metal ceiling tiles incorporate BASF's Micronal phase change material, comprising thousands of microscopically small, polymer-encapsulated spheres, each



PCM viewed under a microscope [Source: BASF]

with wax-core latent-heat storage. Since melting and solidifying happens inside each microcapsule, the material remains solid, even if heat is being taken up or released.

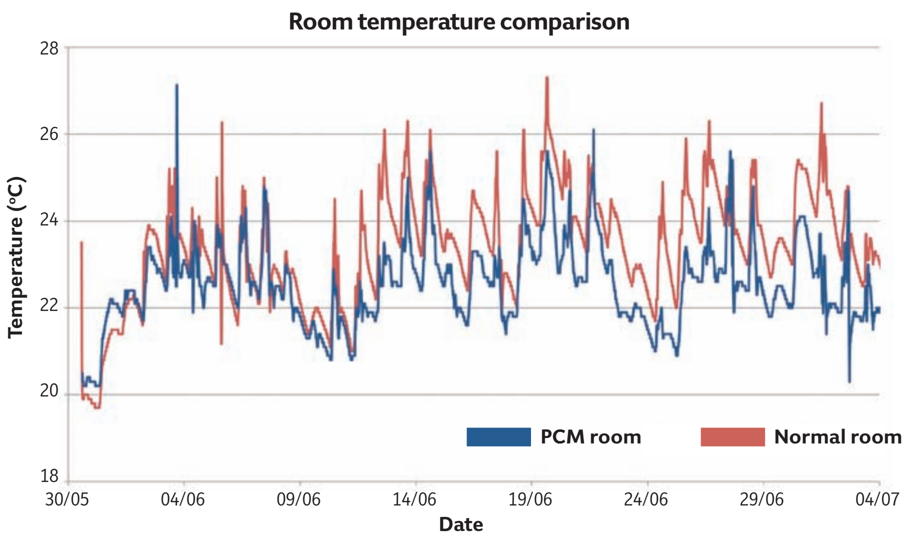
In these tiles, the micro-encapsulated wax will start to melt as air temperatures approach 23°C; as it does so, it soaks up heat from the room. Heat absorption continues until all the wax has changed phase. Using night ventilation, the tiles can release this absorbed heat once the room temperature starts to drop below 23°C. As it releases heat, the PCM will return to its solid state.

The tests at Belvoir High School took place between May and July 2013. The results showed that, when the rooms were sealed during the day and heated using 2.1kW and 4kW loads per room, the room with the PCM ceiling tiles was generally 1-2K cooler than the one with normal ceiling tiles, for both heat loads.

Interior temperatures did not always cool below 23°C on warmer nights, but the room with the PCM tiles was still cooler the following day. This suggests that the PCM had part-solidified – even though the temperature had not dropped below 23°C – and/or the thermal mass of the PCM tiles provide some air temperature buffering, in addition to cooling provided by the phase change of the PCM.

The tests demonstrated that the room with 20m² CoolZone tiles would more easily pass the PSBP output specification criteria as a result of both lower air temperatures and surface temperatures, proving that exposed PCMs can make a difference to providing a comfortable learning environment.

TONY HESLOP is the regional market development manager at BASF



Below-ceiling peak air temperature consistently lower in room with PCM in ceiling tiles

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The safe use of gas in education buildings

This module is on gas safety in education facilities with reference to current UK standards

Standards and guidance publications relating to gas use are changing at an increasing frequency. Some of these documents relate specifically to education premises – though most apply to a wider range of buildings. This CPD focuses on the area of gas safety in education buildings, and refers to current UK standards and guides.

Gas is used in three main areas within an education building:

- Boiler room for gas-fuelled boilers and water heaters
- Preparation of food within the production kitchen
- Classroom applications, such as in science laboratories.

Access to the first two areas is limited to staff and service personnel, but the third group is likely to present the greatest uncertainty and risk, as these – by their nature – are accessible to 'non-competent' persons.

Laboratories

Teacher control of the gas supply in a laboratory is the most effective way to ensure maximum gas safety and teaching-time efficiency. This can be done using a panel fitted behind the teacher's desk that includes a key switch and emergency stop button to control an automatic isolation valve (AIV) .

IGEM/UP/11 Edition 2 (UP11.2[1]), published by the Institute of Gas Engineers and Managers (IGEM), sets down the minimum safety requirements in educational establishments for designers, operators and users. This requires (section 6.2.4.1) that 'where an AIV is required, the system shall include a downstream integrity check before the valve can be reopened'. A practical way to achieve this is by a gas pressure proving system; this will ensure that all gas taps are closed before allowing the use of gas.

UP11.2 (section 6.2.2-3) requires that an 'additional emergency shut-off valve should be fitted in a readily accessible position for use by teaching and technical staff', and continues: 'Where it is not practicable to install a manual isolation valve in a readily accessible position, or where it is required to interlock the gas supply with other safety systems – such as air flow, fire or gas detection – then an automatic means of isolation shall be installed.'

Food technology

Some form of mechanical ventilation will normally be incorporated into the design of a food technology area, to supply fresh air for the occupants and to ensure complete combustion of gas. Any mechanical ventilation should be interlocked with the gas supply such that, in the event of a fan failure, the gas supply will be isolated, as described in BS6173/2009[2] (section 11.1).

A food technology area will normally have a number of domestic-style gas cookers around the room, so it can be difficult to incorporate a cost-effective ventilation solution to remove both the products of combustion and the by-products of cooking efficiently.

IGEM UP11.2 (section 11.2.4) takes this potential issue into account and states that, where the ventilation requirements might not be met, a carbon dioxide (CO_2) monitoring system should be installed. CO_2 monitors should have a warning alarm at a level of 2,800ppm, with 5,000ppm being the level at which the gas must be isolated.

Solutions for teaching and food technology areas would be to install a control and monitoring panel by the main teaching area, to ensure the integrity of the gas supply and equipment by use of gas pressure proving. Such devices can also include the facility to isolate the gas in the event of a high CO_2 level or ventilation-fan failure. A gas pressure proving system for use in a teaching area should be fitted with an emergency gas-isolation button on the panel, as well as a key switch to control gas availability at workbenches. A countdown timer should also be incorporated, to ensure that gas is not available for out-of-hours, unauthorised use.

A well-designed gas pressure proving system ensures that there is no pressure drop downstream of the control valve – that is, no leakage or open appliances – before allowing gas to flow. Two main methods of gas pressure proving are available:

1) **Single-mounted downstream sensor**: This method is assumptive, because it takes a snapshot of the gas pressure upstream of the safety shut-off valve (SSOV) when it is first opened, and then looks downstream of the (subsequently) closed SSOV for a pressure drop. Consideration should be given as to whether it is acceptable for a safety system to be assumptive in its design, in view of more recent technological advances towards fail-safe operation. An example would be that, if the gas supply pressure was too high, for whatever reason – for example, because of a failed regulator – then the valve should not be opened at all, as to do so could create a dangerous situation. Single-sensor systems are not fail-safe where there is an installation problem with the SSOV and a gas leak exists.

2) **Differential pressure sensing**. The other, more recently exploited, method of monitoring the gas pressure is by means of differential pressure measuring. This technique measures the pressure differential across the inlet and outlet of the solenoid gas-supply valve. This provides continuous pressure readings – effectively, during and after the pressure test – so ensuring an accurate safety check is carried out with no assumptions during the testing time.

Such a system can constantly monitor the supply pressure without opening the SSOV – and is fail-safe where a gas leak is also present. Systems that monitor CO_2, CO and combustible gases – as well as controlling the occupancy scheduled ventilation rates, bench water supply and electrical isolation – are available in a single control panel.

Boiler house and plantroom application

Gas detection should be fitted in all new and refurbished boiler rooms where the boiler house forms part of, or is attached to, the main building, as discussed in Building Bulletin 100[3] (3.1.8) and IGEM UP/11. In the event of a genuine fire alarm, both the gas and the electricity supply to the boiler house should be isolated. If an automatic proving device (that is, gas pressure proving) is fitted, then automatic restarting is allowed after an interruption to the building electricity supply. This has a particular advantage – for example, in minimising the potential of pipes freezing after a power-cut during unoccupied weekends and holidays.

IGEM/UP/1A Edition 2[4] requires 'the closure of a valve, for example, the electronic isolation valve (AIV), can result in the complete loss of pressure which necessitates tightness testing and purging before resumption of supply'. This means that if, for whatever reason, the valve closes, a gas tightness test – and, on very large installations, purging – *may* need to be carried out before reopening the valve. Practically, this means that, if the gas pressure has dropped to 5 mbar or less, there is a requirement to test for tightness. A gas-proving system would be able to make this test at a push of a button; the alternative is a physical test by an engineer.

Figure 1: An example of a gas proving system suitable for use in a boiler plantroom

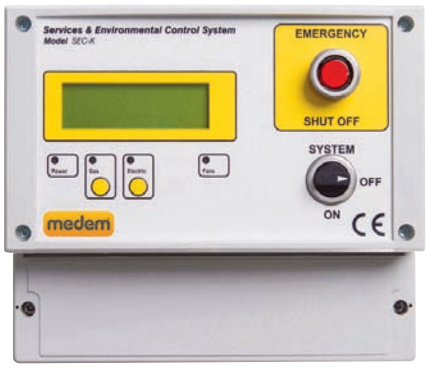

Figure 2: Example of control panel that could be located adjacent to teacher's area in laboratory

Combined gas-detection and pressure-proving systems, designed specifically for use in education building boiler rooms, are available. Combustible gas and carbon monoxide detectors can be connected to such a system, so that – in the event of detecting high levels of either gas – the gas supply would be isolated. An output to a building management system or a visual indicator, such as a flashing beacon, can be mounted outside the boiler room. Otherwise, in the event of the gas being isolated, the building heating and hot-water systems will not operate – potentially resulting in lost teaching time.

The system should be able to isolate the gas in the event of a genuine fire alarm. The system should also have provision for the connection of heat detectors, as referred to in BB100 3.1.8. Any system should be capable of differentiating between a power loss and a potential emergency isolation, so that a subsequent auto restart can be allowed safely.

Catering kitchens

The production kitchen in an education building is a commercial kitchen within the scope of BS6173:2009. It requires the interlocking of any mechanical ventilation systems – including supply air fans – with the gas supply in the kitchen. This includes mechanical extract systems that are not over the main cooking area, but are in the same room, such as a gas-fired steamer with an extract canopy fitted above. If this steamer extract fan is not interlocked then, if it is not switched on, air can be drawn down the steamer extract canopy along with the gas products of combustion. The air is then pulled across the occupied room by the main extract canopy. This is more likely where natural ventilation is used for make-up air.

Secondary interlocking via CO_2 monitoring as part of an interlock package is not allowed in BS6173:2009, as it is considered to be an interlock override. Fixed CO_2 monitoring can form part of the ventilation interlock package, as discussed in IGEM/UP/19.1[5] (section 5.1.2). This is to monitor the free kitchen environment, so the sensors should not be fitted under an extract canopy. For new installations, the maximum allowable level of CO_2 is 2,800ppm, and for existing installations 5,000ppm. The gas supply should be isolated if the CO_2 reaches these levels.

CO_2 levels may also be used as an indicator of air quality in the kitchen, and can give an early indication that the ventilation is inadequate or failing – for example, due to dirty extract hood filters.

IGEM/UP/19 Edition 1 *Design and application of interlock devices and associated systems used in association with gas appliance installations in commercial catering establishments* has recently replaced the withdrawn Gas Safe Technical Bulletin 140 (TB140).

Flame-safety devices on cooking appliances can take up to 10 seconds to close. This can result in partial, or complete, loss of gas pressure after the closure of an upstream AIV, for whatever reason. Therefore, a gas pressure proving system can usefully form part of any interlock package, allowing for a more practical system restart to comply with the requirements of IGEM/UP/1A Edition 2, as discussed previously. The disengagement of flexible hose bayonet connectors in kitchens can also lead to pressure loss in the distribution pipework.

Systems are now available that carry out the functions of interlocking the ventilation with gas supply, proving the gas cook line gas tightness of the appliances, as well as monitoring the carbon dioxide level in the atmosphere. Where required, such a system can also adjust the ventilation rates, depending on the amount of activity in the kitchen, by monitoring the CO_2 levels and the kitchen temperature.

As long as the ventilation system has been correctly specified, then the installation of a good-quality safety and monitoring system as described will ensure comfort and maximum safety in the kitchen. Using integrated displays, these panels can provide the users with quick-reference visual indication of the state of the system, the environment, and the gas status.

References:

1 *IGEM/UP/11 Edition 2 Gas installations for educational establishments*, IGEM 2010.

2 *BS6173:2009 Specification for the installation of gas-fired appliances for use in all types of catering establishments (2nd 3rd family gases)*, BSI 2009.

3 *Building Bulletin 100: Design for fire safety in schools*, DCSF 2014.

4 *IGE/UP/1A Edition 2 Strength testing, tightness testing and direct purging of small low pressure industrial and commercial Natural Gas installations*, IGEM 2005.

5 *IGEM/UP/19 Edition 1 Design and application of interlock devices and associated systems used in association with gas appliance installations in commercial catering establishments'*, IGEM 2014.

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Figure 3: Ventilation in catering kitchens can be interlocked with gas proving systems

Module 76

April 2015

1. **Which one of these explicitly requires a downstream integrity check before an automatic isolation valve is reopened in educational establishments?**

- ☐ A *BS6173:2009 Specification for the installation of gas-fired appliances for use in all types of catering establishments (2nd 3rd family gases)*
- ☐ B *Building Bulletin 100: Design for fire safety in schools'* DCSF 2014
- ☐ C *IGE/UP/1A Edition 2 – Strength testing, tightness testing and direct purging of small low pressure industrial and commercial Natural Gas installations*
- ☐ D *IGEM/UP/11 Edition 2 Gas installations for educational establishments*
- ☐ E *IGEM/UP/19 Edition 1 Design and application of interlock devices and associated systems used in association with gas appliance installations in commercial catering establishments*

2. **What monitoring does IGEM UP11.2 require if ventilation requirements might not be met in a food technology area?**

- ☐ A CO monitoring
- ☐ B CO_2 monitoring
- ☐ C Electrical supply monitoring
- ☐ D Gas flow monitoring
- ☐ E Gas pressure monitoring

3. **What is practically taken to be the minimum drop in pressure, triggering the need for a tightness test, after the closure of an AIV in a gas supply for a boiler house?**

- ☐ A 3 mbar
- ☐ B 4 mbar
- ☐ C 5 mbar
- ☐ D 6 mbar
- ☐ E 7 mbar

4. **For new installations, what is the maximum level of CO_2 allowable before the gas supply is isolated?**

- ☐ A 800ppm
- ☐ B 1,800ppm
- ☐ C 2,800ppm
- ☐ D 3,800ppm
- ☐ E 5,000ppm

5. **Which of these documents has superseded Gas Safe Technical Bulletin 140?**

- ☐ A BS6173:2009
- ☐ B BB 100
- ☐ C IGE/UP/1A Edition 2
- ☐ D IGEM/UP/11 Edition 2
- ☐ E IGEM/UP/19 Edition 1

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