Case study: Review of control strategy for a primary school built to PassivHaus standard

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CASE STUDY: REVIEW OF CONTROL STRATEGY FOR A PRIMARY SCHOOL BUILT TO PASSIVHAUS STANDARD

AUTHORS

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CONTEXT

Patterns of occupant behaviour, user and automated controls, window operation control strategies, Building Management System (BMS) features and settings in primary schools can be responsible for a performance gap and affect the conditions of indoor learning places. The post occupancy stages of the Soft Landings framework, while costly, can help identify the often unaccounted for factors relating to the access to controls, management and maintenance and the potential requirements for changes and adjustments. Sharing lessons learnt can prove a helpful guide for the future design of building systems of control strategies of PassivHaus (PH) primary school buildings.

AIM AND METHODOLOGY

This case study reports on the findings of an ongoing Soft Landings project, which aims at ensuring that controls and environmental strategies perform as expected and are straightforward for the occupants of a PH primary school building to understand and use. The case study investigated a series of issues regarding commissioning of components, seasonal adjustments of strategies and other factors that affect indoor environment conditions. More specifically, the evaluation of BMS settings and interface, the usability of controls and effectiveness of environmental strategies were based on an Architect-led control strategy review and evaluation workshop with representatives from the interdisciplinary design and Soft Landings team, school users and the building Facilities Manager (FM), a walkabout and sampling measurements. Evidence from a questionnaire survey and longer term monitoring of

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conditions in selected spaces (from October 2014 to January 2015) suggested there were associations among occupant perception and behaviour patterns, BMS setpoints and indoor conditions.

THE BUILDING

The case study primary school was occupied in December 2013. It is a 2-storey timber-frame construction, built to PassivHaus standards, hence well insulated and airtight. Classrooms, offices and other spaces are located around a double-height hub space with circulation spaces, day lit from south.

ENVIRONMENTAL AND CONTROL STRATEGY

In winter the building has Mechanical Ventilation (MV) with heat recovery (HR). Fresh air is supplied to the classrooms and then transfers to the hub-space through sound attenuated air paths. Air is then extracted from the hub space and WCs at high level and leads to the thermal wheel, which is located in an external Air Handling Unit (AHU). MV air change rates (fan speed) are controlled based on return air CO_2 levels (ppm), measured in the return air duct.

In summer the building is naturally ventilated. Classrooms are equipped with manually operated windows and ventilation panels. BMS operated high-level windows are provided in the hub space and roof lights over ground floor circulation spaces at one end. The BMS operated windows are controlled based on air temperature, measured at the hub space at 1.50 m from the first floor level, as an overheating prevention mechanism.

INITIAL EVALUATION OF STRATEGIES

The Soft Landings team became aware of indications that the environmental strategy was not ideally performing going into winter: including concerns from the occupants over thermal discomfort and draught in a number of classrooms and the ground floor hub-space and also randomly opening high-level windows. The school FM and Headteacher were concerned about their level of understanding and options regarding the building controls and systems. The investigation of a variety of factors believed to cause the above concerns was discussed along with a number of interventions.

INTERVENTIONS

A number of proposed interventions, their implications and outcomes, are presented here.

REVIEW OF BMS SETPOINTS

Investigations found that BMS setpoint values and settings that control indoor air temperature, and air change rates need to be adjusted during the first year of occupancy according to occupants requirements, actual sensor locations and delivered systems. In this case, the relationships between the various points were incorrectly scripted, often causing conflicts between systems with an impact on performance. For instance, the CO_2 concentration sensor that controlled the MV air change rates was incorrectly placed resulting in an underestimation of CO_2 concentration. Longer term monitoring of CO_2 levels in the classrooms was useful to decide if adjusting the setpoint or relocating the sensor would be an improvement. Another example is that the imbalance in the AHU that caused low supply air temperatures was attributed to a BMS setting relating to the extract damper of the hub space. The building users and FM were understandably not able to spot this problem.

AUTOMATIC CONTROL OF NATURAL VENTILATION

Building users perceived high-level window operation in the hub space as random and "opening when not needed", and associated them with draught and cold sensation on the ground floor and classrooms. This indicated that there was a possible requirement to increase the overheating threshold that triggers window opening (initially at 24 °C = normal room temperature + 2 °C). This could be also associated with the sensor location and stratification in the double height hub space. It also pointed out that override provision was problematic in terms of effectiveness as not transparent for users.

An alternative strategy was proposed. This included manual operation of high-level windows by setting a much higher overheating threshold, to allow natural ventilation on demand. However, occupant controlled windows outside the classrooms can be easily forgotten leading to a slow response to overheating. As window operation in the hub space becomes more dependent on occupant preferences it is essential that the building user guide explain override switches and training be provided. In this case, increasing the occupants' level of control may increase overheating risk. Monitoring of indoor temperatures was employed to investigate how the vertical difference between high-level windows in the hub space and classroom floor level affected thermal comfort, while draught discomfort was higher in the ground floor classrooms. The questionnaire survey suggested a connection between the classroom door being left open and average air temperatures during occupied hours.

SUMMER MODE VENTILATION STRATEGY

The manually operated natural ventilation strategy for summer means that classrooms rely on teachers opening windows to maintain the recommended CO_2 levels. This strategy has been found to greatly depend on teachers' awareness. In order to raise awareness, training and/or window opening "traffic-light" systems in the classrooms are required. During the first summer of the school's operation, a hybrid ventilation strategy was employed for summer, further reducing CO_2 concentration levels in classrooms and increasing airflow for cooling. Keeping the MV running in summer has the additional benefits of simplicity, of the transition between seasonal modes, control-wise, with a small cost implication. Hybrid ventilation ensures adequate air change rates without compromising other aspects of classroom conditions (e.g. noise from open windows) while avoiding the ingress of outdoor pollutants through open windows.

OCCUPANT AND FACILITIES MANAGER TRAINING

Concerns about building users lack of understanding of the controls and how systems are supposed to work are not uncommon in buildings, especially within the first year of occupancy. The systems were reviewed having the end user in mind. Proposed interventions include producing and making available a non-technical user guide, to be developed in cooperation with the school user representative (the headteacher) in order to ensure it covers all the required areas, it is clear and usable, available in print and electronic form and to be accessible on the BMS site. User training sessions at an early stage were found to be necessary. Developing an up-to-date user guide (among the first to be produced for PH schools) with the facilities manager and building users will also represent progression with regard to simplification of the control protocols and defining of necessary levels of user intervention and understanding of the installed systems.

Other measures to ensure that the systems and controls are transparent to the users include: a) labeling components, such as BMS sensors and switches, b) ensuring override buttons are well-located and self-explanatory, c) the BMS interface is usable on a non-technical level too, with only necessary information. At a later stage, the case study suggested using up-to-date technology e.g. mobile applications and graphics to make the BMS interface friendlier, as this could significantly improve users willingness to learn and be involved. Because of the complexity of controls, the building facilities manager, is an integral part of the building operation. Relying on FM and user training for a building to perform to expectations needs careful consideration while ensuring the school has access to support for troubleshooting.

CONCLUSIONS

This case study showed a BMS can be too complex for the building facilities manager of a primary school building in the UK and occupants of a primary school; leading to a sense of limited control and lack of understanding of how everything works, and eventually to occupant dissatisfaction. The employed control strategy needs to be within the school’s capability to comprehend and manage. Taking into consideration the need for investing in user and FM training, optimization of the usability of the interface, fine tuning of systems and technical support contracts. Proposed adjustments include further restricting the use of actuators, even in circulation spaces. Inside the classrooms, where actuators were avoided, systems that recommend (instead of taking over) the correct use of manually openable windows and vents are considered. It can be concluded that more basic controls with less automation should be employed in the future. Problems with the BMS operation relate to rushing through the end of the construction period. Lessons learnt at the post occupancy stages of Soft Landings in this case study could be taken into consideration at early and handover stages in similar future projects.

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