Case study on the energy performance of the Zuckerman Institute for Connective Environmental research (ZICER) building.

Magazine

ASHRAE Transactions
July 1, 2006 | Turner, C.H.; Tovey, N.K. | Copyright

ABSTRACT

In the early 1990s, the University of East Anglia in Norwich, UK, established a low-energy policy toward building design. In 1994, the first energy-efficient educational building was constructed on campus--the Elizabeth Fry building, which utilizes a hollow core ventilation system. Independent reviews at the time demonstrated that this was one of the best energy performing buildings in the UK. Several additional educational buildings of similar design have been built on campus, one of which is the Zuckerman Institute for Environmental Connective Research (ZICER) building, completed in 2003. The construction of the ZICER building is unusual. The main building envelope is served by a hollow core ventilation system, high in thermal mass, highly insulated and airtight, but on the opposite spectrum, a light weight, highly glazed structure made up of photovoltaic cells was added onto the building to make up the "Top Floor," home to an exhibition area and seminar room. This paper investigates the energy performance from the ZICER building's long-term submonitoring results and explains how the heating and cooling strategies evolved to meet half the building's energy consumption.

INTRODUCTION

The University of East Anglia (UEA) was established in 1963 on a campus approximately 4 km west of the city of Norwich. The initial development phase of the campus centred around buildings constructed in the mid to late 1960s, many of which represent wasteful energy approaches to building design but are now Grade II buildings (buildings in the UK of special architectural or historic interest, warranting efforts to preserve them), so the scope for improvements in thermal performance is limited.

Since the early 1990s, energy savings and conservation through technical means of low-energy building design, good building energy management, and awareness raising have been important aspects of policy and research at UEA. Over this time the campus has expanded in size, which has resulted in the construction of many new structures built to strenuous green design guidelines.

Among these buildings are four, soon to be five, educational office buildings employing the hollow core ventilation system: the Elizabeth Fry building (EFry), the Medical School (MED), the Zuckerman Institute for Connective Environmental Research (ZICER), and the School of Nursing and Midwifery (NAM).

The hollow core ventilation system used is a mechanically ventilated, low-energy heating and cooling system that utilizes concrete hollow core ceiling slabs as supply air ducts to the space (see Figure 1). The high thermal mass of the concrete slabs is used to store heat and coolness at different times of the year. The hollow cores running through the slabs enhance the access to this thermal capacity, which releases heat to or absorbs heat from the air that passes through. The hollow core ventilation system is used in conjunction with regenerative heat exchangers to recapture energy by transferring the heat or coolness from the exhaust air to preheat fresh incoming supply air in winter and to precool the supply air in summer. High insulation standards and good airtightness is also required.

[FIGURE 1 OMITTED]

This paper focuses on the energy performance of the third hollow core ventilated building to be built on the UEA campus, the ZICER building.

CASE STUDY DESCRIPTION

Case Study Building Details

The ZICER building (see Figure 2), built in 2003, is four stories plus a basement, with a total floor area of 2860 [m.sup.2] and a conditioned floor area of 2633 [m.sup.2]. The building is divided into two construction types.

The main building envelope encapsulates the basement, the ground, the first and second floors, and the main plant room and stairwells on the third floor. This main part of the building is served by the hollow core ventilation system. The envelope is high in thermal mass. Dense concrete blocks with a thickness of 23 cm were used for the external walls. These concrete walls are exposed to the interior with the insulation on the outer surface. The envelope is airtight, with an air permeability of 2.84 [m.sup.3] x h x [m.sup.-2] at 50 Pa. The U-factor for the external walls and floor is 0.2 W[m.sup.-2] x [degrees][C.sup.-1], the roof has a U-factor of 0.13 W[m.sup.-2] x [degrees][C.sup.-1], and the triple-glazed low-emissivity windows have a value of 1.1 W[m.sup.-2] x [degrees][C.sup.-1]. These insulation standards exceed the current UK building regulations.

The basement of the building is a virtual reality suite. It has an extensive amount of computer equipment but is infrequently used. The ground floor and the first floor are large open-plan offices for post-graduate students and researchers. These floors have cellular offices along the west of the building for faculty members. These two floors have high internal heat loads due to many people and lots of computing equipment. The second floor is entirely composed of cellular offices. This floor is for senior members of faculty and administrators.

[FIGURE 2 OMITTED]

The remainder of the third floor, referred to as the "Top Floor," is light in construction with a low thermal mass. The space is divided between an exhibition area and a seminar room. The southern facade and roof of the Top Floor are almost entirely glazed by photovoltaic (PV) cells. The heat losses and heat gains are high due to the large expanse of glazing. The glazed Top Floor is a demonstration project for the integrated PV cells.

The Operation of the Hollow Core Ventilation System

The operation of the main part of the building served by the hollow core ventilation is illustrated in Figure 3. Incoming air through the centralized air-handling unit (AHU) is preheated in winter and precooled in summer by the regenerative heat exchanger (RHE) and supplied to the hollow cores in the pre-cast concrete slabs via the supply duct for each floor. Each floor has its own heater battery to increase the supply air temperature if required. The circulating air passes through the hollow cores at low air velocities to allow prolonged contact between the air and the slab in order to transfer the heat or coolness to the supply air. After passing through the ceiling slabs, the air enters the internal occupied spaces through circular ceiling diffusers. The return stale air for each floor is extracted via the grilles in the bulkhead, up the extract duct and out ...