Paper No 197: The remodelling of Ashburton Court: implementing natural ventilation in an existing urban building

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Abstract

The remodelling of Ashburton Court in central Winchester for Hampshire County Council will eventually provide over 12,000m^2 of accommodation. The project employs a passive wind-driven natural ventilation strategy and re-uses an existing concrete frame within a sensitive, historical urban setting. Its remodelling builds on the architect's previous experience of a series of new-build, low-energy office buildings, while also facing the additional physical, aesthetic and environmental constraints of an existing building on an urban site. Together the implementation of natural ventilation and the re-use of an existing frame have reduced the whole-lifecycle environmental impact to less than half that of an equivalent new-build mechanically ventilated office building, while also transforming its appearance and working environment. This paper begins by outlining the wider technical and physical context of the project, then moves on to establish the environmental case for urban re-use and natural ventilation, before describing the implementation of a wind-driven ventilation system that simultaneously addresses environmental and townscape issues. As such the paper describes an approach where the emphasis is placed as much on inherent architectural technique as on applied technology.

Keywords: urban context, natural ventilation, refurbishment, office buildings, passive design, thermal comfort

1. Introduction

The remodelling of Ashburton Court in the centre of Winchester is the latest in a series of office buildings by Bennetts Associates (BA) that have been at the forefront of sustainable design in the UK. Ashburton Court was originally constructed in the 1960s as an annex to Elizabeth II Court, Hampshire County Council's (HCC) main headquarters. It has however suffered from many of the technical and aesthetic shortcomings synonymous with the period. Following a feasibility study, HCC decided to refurbish the building rather than move to a new building further away from its central Winchester HQ. Although HCC itself has a very highly respected architects department, its experience was mostly in educational, housing and cultural projects. It was therefore decided to appoint another architect with more expertise in the design of office buildings. Following the required OJEU (Official Journal of the European Union) submission process BA was appointed in December 2005, along with Ernest Griffiths and Partners (EGP) as services engineer. BA and EGP first worked together on PowerGen and have worked together on many subsequent projects. The resultant design is the outcome of a close collaboration between HCC's Head of Architecture, BA and the rest of the design team. The first phase was completed in Jan 2008 and the second phase is scheduled for completion in June 2009.

2. Previous Projects

The design of Ashburton Court builds on the experience of previous projects, while also facing the additional physical, aesthetic and environmental constraints of an existing building on an urban site. It can be seen as part of an evolving series of buildings dating back to Rab Bennetts' experience working on the naturally ventilated 'Gateway Two' while still at Arup Associates. Collectively this set of buildings helped to develop an approach to the architecture of office buildings that has explored many facets of sustainability. It is important to briefly introduce two examples of that evolution in order to set the technical context of Ashburton Court.

2.1 PowerGen

The headquarters for the newly privatised utility company PowerGen was completed in 1994 on the outskirts of Coventry. Careful analysis of local weather data had shown that the preverbal 'hot still day' didn't exist, certainly not over a number of days. The use of early CFD (Computational Fluid Dynamics) analysis by EDSL (the same modellers were used on Ashburton Court) showed that wind pressure rather than stack effect would be the strongest ventilation motor during summer days. The building is two simple 12.5m wide floorplates with a central atrium space in between. It is orientated along an east/west axis, so that the long facades are easy to shade. High heat emitting functions that would require mechanical ventilation (such as meeting and IT rooms) were removed from the office floorplates and collected at the east and west ends of the building to act as a thermal buffer. The thermal mass of the in-situ concrete structure was exposed to act as a heat sink during the day, which is then purged at night. Together this meant that the main office spaces could be naturally ventilated. Monitoring has confirmed that cross ventilation has worked well and proved to be the stronger motor during summer days.

2.2 Wessex Water

After several projects following PowerGen, Wessex Water was completed in 2000 on a brown field site on the outskirts of Bath. It employed a similar operational energy strategy to PowerGen, but then pioneered new methods for reducing the embodied energy content of the building, as well as for water, bio-diversity and transport impacts. It has also been extensively monitored in use [1]. At the time of its completion Wessex was rated as the 'greenest office building' in the UK by the BRE (Building Research Establishment).

Fig 1. Wessex Water (Peter Cook)

3. Ashburton Court and its Constraints

The series of buildings from PowerGen to Wessex developed a typology for sustainable office buildings and Ashburton Court presented an opportunity to evolve that typology further in the re-use of a city centre building. Clearly any project in a city centre or an existing building is significantly more complex than one on a green (or indeed brown) field site. This is especially the case if the project is to be largely naturally ventilated.

3.1 Ashburton Court Existing Building

The building is composed of two main blocks, the smaller east block and the 'L' shaped north and west block, which together form a large courtyard. The blocks were elevated above an open air podium car parking level that belonged to HCC, with the podium itself forming a two storey public car park. This car park was on a long term lease to Winchester City Council and was outside the remit or influence of the project, other than the opportunity to re-clad it externally. While the cladding, internal fittings and services were beyond their working life, the in-situ concrete structural frame was in good condition. The existing building and its context presented the design with a number of challenges, which are outlined below.

Fig 2. Existing east block before the removal of the existing cladding panels

3.2 Acoustic Restrictions

The most significant limitation to the building's design was the site being surrounded on three sides by trafficked streets. Studies carried out by Arup Acoustics had concluded that any ventilation system could not rely on windows opening to the streets. This seemed to preclude the natural cross ventilation that had worked so well on previous projects.

3.3 East and West Facades

To compound matters further, unlike previous projects, the main facades of Ashburton Court had been determined by the street pattern and, as an existing building, could obviously not be re-orientated. Unfortunately the overwhelming majority of the facades faced either east or west, meaning the worst possible orientations, which suffered from low angle morning or afternoon sun respectively.

3.4 Limited Floor to Floor Heights

Comparatively limited floor to floor heights ruled out displacement ventilation, due to insufficient space for the stratification of air to take place. Maintaining comfortable summer temperatures would have therefore necessitated higher than comfortable air velocities. This eliminated the option for a low energy active ventilation system that would probably have been the default environmental solution for a new build. Consequently, comfortable ventilation was essentially a binary choice between four pipe fans coils within a suspended ceiling and natural ventilation with exposed thermal mass. In this case the restrictions of re-using a building drove a more innovative solution than would probably have been the case with a new building.

3.5 Townscape and Design

As well as the environmental difficulties, the project is also located in the centre of one of England's most historic and beautiful cities. The existing building was set back from the road and raised two storeys from the ground, which divorced the building from the surrounding streetscape. Its architecture was also relentlessly horizontal, in a city that is mostly vertical nature. The materials, mostly pre-cast concrete cladding units, were also clearly at odds with the city. The consistent use of one material resulted in distant views where the building appeared as one single monolith from. Consequently, there was a desire to break down the mass of the building into a series of bays and to introduce a more vertical rhythm that would reconnect the building to the street and reflect the typology of the city.

4. Holistic Environmental Analysis

Clearly as the operational energy impacts of office buildings are reduced it is important to consider wider environmental impacts. Early in the project a series of studies were used to verify the assumed arguments for both urban re-use and natural ventilation.

4.1 Lifecycle Analysis

In order to better understand the relative importance of different impacts a desktop study was carried out early in the project using benchmark data for operational, commuting transport and embodied energy. It was compiled using data taken from Econ19 [2], BREEAM [3] and Envest [4] respectively and the calculations assumed a gross occupation density of 15m^2 per person. The results are illustrated in Fig 3., which shows lifecycle CO_2 impact per occupant over 40 years for four different scenarios:

1) standard air-conditioned edge of town.
2) naturally ventilated edge of town.
3) naturally ventilated city centre
4) naturally ventilated city centre, with re-use of structural frame

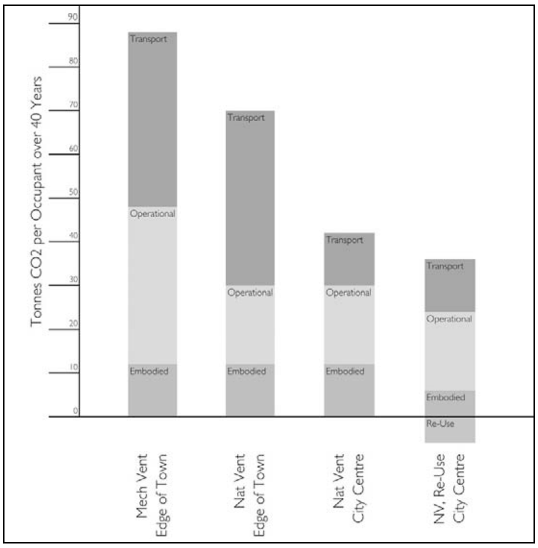

Fig 3. Lifecycle CO_2 impact per occupant

With a mechanically ventilated building on the edge of a town operational energy is the most significant impact, closely followed by commuting transport. Changing to natural ventilation therefore reduces the overall impact significantly. Thereafter however, the greatest reduction is to be found in locating a building close to a major public transport interchange. In practice this means a city centre site, though this of course makes the implementation of natural ventilation much more difficult. The embodied energy remains about the same for all four scenarios. Therefore as operational and commuting impacts are reduced the reuse of the structural frame makes a much greater proportional difference than it would have done.

4.2 Envest II Analysis

The actual embodied impact of the building was analysed in depth using the BRE's software Envest II [4]. This had first been used by BA on Wessex Water. It provides a comparative holistic environmental impact assessment of a building's construction, operation, maintenance, repair and disposal over its whole lifecycle. Given that the environmental impacts of construction encompass a wide range of issues, from climate change and mineral extraction to ozone depletion and waste generation, BRE developed Ecopoints [5]. This is a single score composite environmental assessment of a particular product, process or operation and are the units of output for Envest.

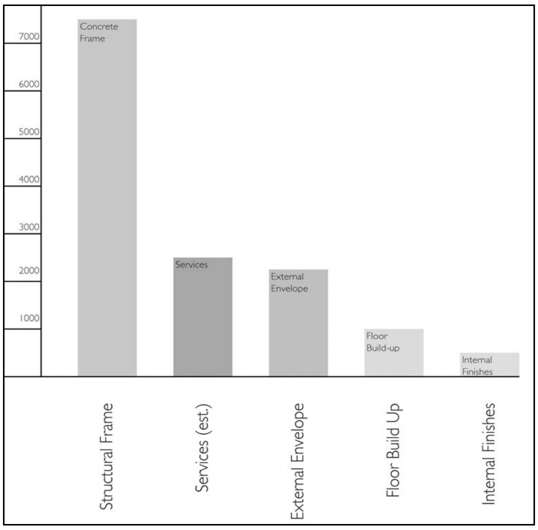

Fig 4. Lifecycle Ecopoint impact per element

The results of the lifecycle study are summarised in Fig 4. This showed that the structural frame, including sub-structure, dominates the lifecycle impact. Retaining the existing structure therefore approximately halved the embodied impact of the building's construction.

4.3 Operational Energy Benchmarks

Clearly benchmarking the operational energy use of the project against the existing building and current best practice was important. The main benchmarking document used in the UK is EGC19 [2]. However this was last revised in 2003 and is now considered by some to be insufficiently onerous. Arups R+D had been employed by the Carbon Trust to advise the project and to carry out post occupancy evaluation. Together with Arups, the Design Team set a target of EGC19 best practice, minus 30%. This resulted in a target of 25-30 $kgCO_2/m^2/a$. This includes the necessarily air conditioned functions, such as meeting, conference and print rooms, but does not include small power, the restaurant kitchen or IT suite. The target is about the same as the measured in use performance of Wessex Water, although it is in a much more demanding context than Wessex. Arups also monitored one of the existing blocks before refurbishment for one year. Eventually this will allow a direct comparison with the existing building.

4.4 Renewable Contribution

In the UK various planning authorities have introduced a renewables obligation, which usually require either 10 or 20% of a building's regulated energy consumption [6] to come from on-site renewables. An unintended side effect of this has often been to concentrate design effort and project finance on the renewable generation of energy rather than on reducing energy consumption to a minimum as a crucial first step.

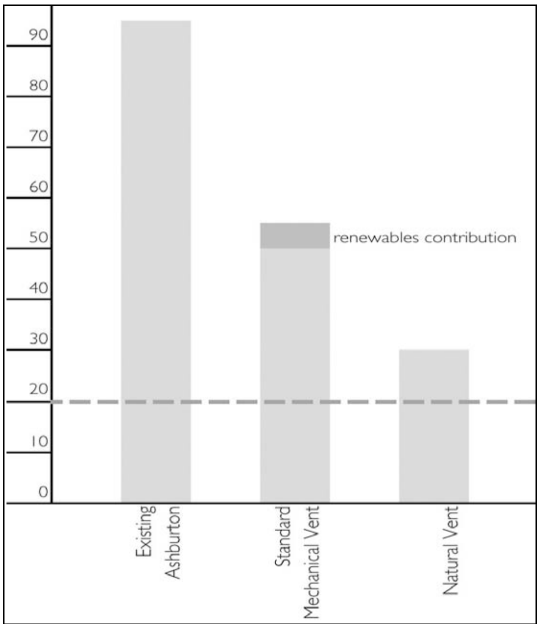

Fig 5. kgCO$_2$/m^2/a for existing and refurbished building

This has recently been the subject of a number of reports from the UK Green Building Council [7]. By engineering the fundamental form of the building well, greater reductions in overall CO_2 impact can be achieved than by relying on (often quite unreliable) renewable technologies. However, contrary to popular opinion, naturally ventilated buildings are not less expensive than mechanically ventilated ones. This is due in large part to the increased complexity of the BMS (building management system). The significant number of actuators needed to open and close windows can double the cost of the BMS compared to that of a mechanically ventilated building [8]. Fig 5. was used to illustrate the benefit of natural ventilation to the planners. It shows the savings of a building regulation compliant mechanically ventilated building with 10% (theoretical) renewable generation and a naturally ventilated building with no renewables, and compares them to the measured energy consumption of the existing building. This quickly convinced doubters of the benefit of additional expenditure being on energy reduction measures rather than energy generation. It also demonstrated a design approach in which sustainability is inherent to conception and fundamental form of the building, rather than being treated as a bolt-on extra.

5. The Design

The previous sections have covered the context of the project, its challenges and it aims. The following section describes how those were dealt with in the design and conception of the building. It also explains how the synthesis of architecture and environmental engineering was used to not only reduce the energy consumption of the building significantly, but also to transform the massing, external expression and townscape of the project.

5.1 Massing Alterations

A number of key massing moves altered the form of the building. In order to reduce the perceived height of the building the top floors were removed and in some places replaced with smaller structures. Removing 250 car parking spaces allowed the open air podium to be infilled with accommodation. The loss of parking spaces was overcome by a new park-and-ride scheme. Infilling the podium level space beneath the buildings both compensated for the accommodation removed from the top floors and helped to connect the blocks to the podium and street. A series of new podium level pavilions will eventually form a new reception, restaurant/café and auditorium, while also creating two external courtyards at podium level.

5.2 Wind Driven Ventilation Strategy

The previous experience of the design team was that wind pressure rather than thermal buoyancy was a much more powerful motor of summer daytime ventilation in office buildings.

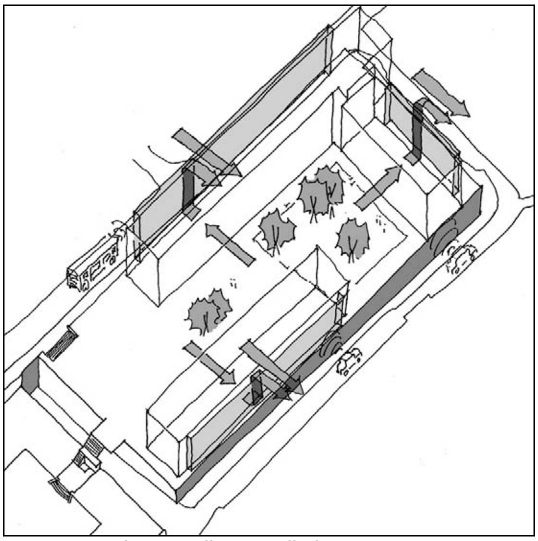

Fig 6. Outline Ventilation Strategy

Given that the acoustic restrictions around the site precluded simple cross ventilation, a strategy was developed that exploits the pressure differentials of wind movement over the top of the building. It is illustrated in Fig 6. Ventilation air is drawn into the building from the courtyards, across the floorplate and then up acoustically attenuated ventilation ducts on the street facades of the building. The motor for the air movement during the day in summer is wind movement over open topped wind troughs, which ensure that there is negative pressure, irrespective of wind direction. The strategy enabled wind driven ventilation that does not rely on opening windows to the street facades.

5.3 Main Architectural Components

The design is a complex synthesis of several different challenges. The key components are illustrated in Fig 7.

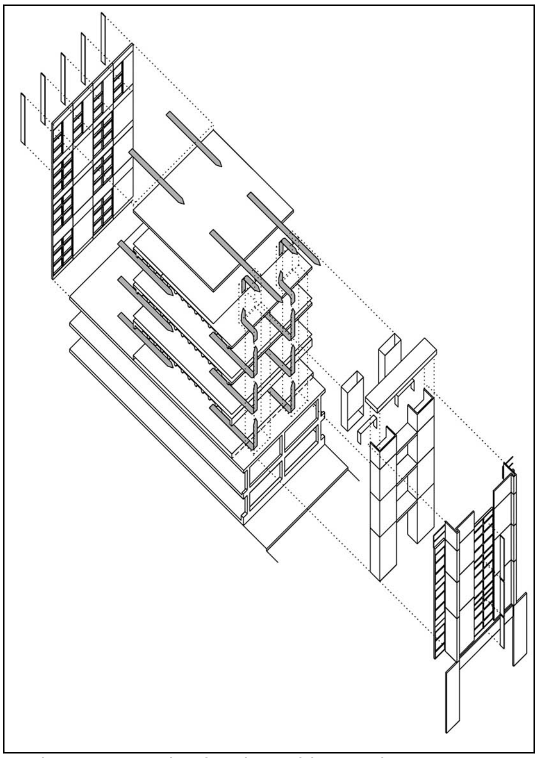

Fig 7. Bay Study of Main Architectural Components

1) Existing Structure - the cladding panels were removed and crushed for use as hardcore in other HCC projects. Internal fittings were also stripped out in order to expose the thermal mass of the existing structure. The thermal mass acts as a heat sink during the day, contributing something in the order of 25w/m^2 of additional cooling.

2) Courtyard Façade - this was re-clad with a simple timber/aluminium composite cladding system. The glazing ratio was kept below 40% to balance the need for light with mitigating solar heat gains. High level windows are BMS controlled to allow ventilation air into the building from the courtyard. Lower windows, while not assumed as being open by the thermal modelling, can be operated manually by the occupants.

3) Ventilation Ducts - these are acoustically attenuated and used to draw air out of the building. They are formed by a steel structure 'clipped' to the street façade of the existing structure and bearing onto the podium slab. As well as forming the ducts this also pushed the façade of the building out to the street edge. As with the courtyard facades the glazing ratio was kept to below 40%. The depth of the ducts also provided shading from low angle morning or afternoon sun on the east and west facades.

4) Wind Troughs - these provide the 'motor' at the top of the ventilation ducts. They are open topped boxes that create negative pressure (suction) irrespective of wind direction. A BMS controlled vent at the top of the ventilation ducts opens into the wind trough and is used to control air movement.

5) Street Façade Windows and Brickwork - the cladding to the ventilation ducts and street façade is a simple timber/aluminium composite system, once again with a low glazing ratio of below 40%. The brickwork was used to articulate a series of bays that re-connect the building to the street level and introduce a vertical emphasis to counter the horizontality of the original building. Due to structural limitations, brickwork could only be used on the outer facades of the building, which again helped to break up the blocks of the building. Windows on this façade can be manually opened if occupants wish to, but do not form part of the ventilation strategy.

5.4 Wind Tunnel Testing

The design of the building underwent extensive computer modelling by EDSL, using its TAS software. Local weather data was used, but a decision was made to use warmer temperature data for London to simulate the effects of increased temperatures due to global warming over the next thirty years. Due to the complexity of air movement around buildings, the results were also verified by a number of wind tunnel tests in Cardiff [9]. The pressure differential between each wind trough and associated courtyard opening window was tested to ensure that negative pressure was always present. This was done for 16 points of the compass. Two areas were found to not always have negative pressure within the wind trough. These were the southern end of the east block, due to wind rising over the higher neighbouring Elizabeth II Court, and the north end of the west block, where there was no route into the building for air at courtyard level. As with previous projects, these locations were used to accommodate functions that would need mechanical ventilation anyway, such as meeting and print rooms. Fig 9. shows the building plan with pressure difference coefficients plotted for the 16 compass points.

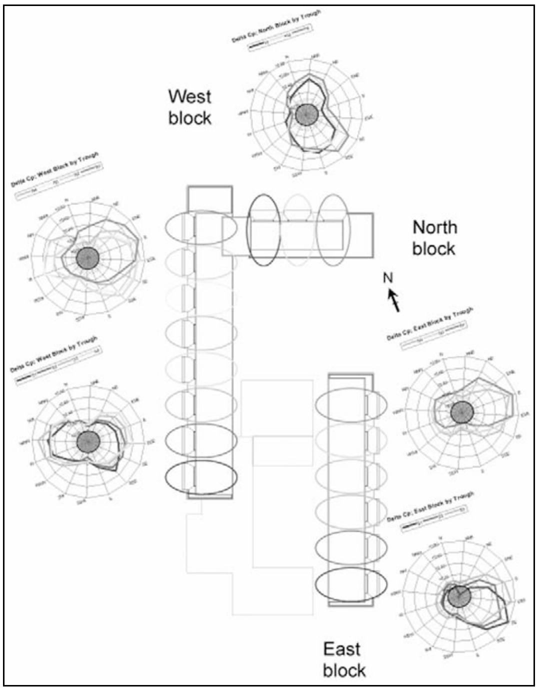

Fig 8. Wind Tunnel Test Results imposed on typical floor plan

Fig 9. Remodelled exterior, taken from same position as Fig 1.

Fig 10. Interior view of refurbished floorplate

6. Conclusions

Ashburton Court was clearly a challenging project, but with a supportive client and a strong design team it has pushed Bennetts Associates' evolving environmental office typology into both an urban context and the re-use of an existing frame. Together it is predicted that this should more than halve the lifecycle environmental impact of the project compared to the construction of a conventional new-build mechanical building on the same site. The wind-driven ventilation system is predicted to more than half the operational energy use and without employing renewable technologies. This is equivalent to results only previously achieved in buildings located on the edge of towns. The basic strategy though, while driven by the challenges of re-use, is equally applicable to new buildings. At the time of writing initial anecdotal evidence on the performance of the ventilation system in the first phase is very encouraging. The Carbon Trust has commissioned Arups R+D to carry out post occupancy evaluation of the building and to compare this directly to the last year of occupation before people were moved out of the existing building. By October 2008 the initial numerical data covering the first summer of occupation should be available.

7. References

1. Knutt, E., 'Cutting the Greenwash,' *Building Design* (24.03.06).
2. Energy Consumption Guide 19: Energy use in offices (2003). This can be downloaded from The Carbon Trust website - www.carbontrust.co.uk
3. BREEAM (Building Research Establishment Environmental Assessment Method) - further information available online at www.breeam.org
4. Envest II - further information available online at http://envestv2.bre.co.uk/.
5. For further information on Ecopoints see either BRE Digest 446, 'Assessing environmental impacts of construction: Industry consensus, BREEAM and UK Ecopoints' or www.bre.co.uk/filelibrary/cap/076.pdf.
6. Regulated energy consumption is covered by the Building Regulations and as such does not include small power or special uses, such as kitchens or IT suites. It also doesn't cover lifts, security systems and external lighting.
7. UKGBC (2007), Carbon Reductions in New Non Domestic Buildings. This can be downloaded from the UK Green Building Council's website: www.ukgbc.org.
8. This is currently the subject of a detailed cost benchmarking study being carried out by Davis Langdon with BA, which will be published in due course.
9. This is part of the Welsh School of Architecture in Cardiff. For further details refer to: www.cardiff.ac.uk/archi/windtunnel.php.