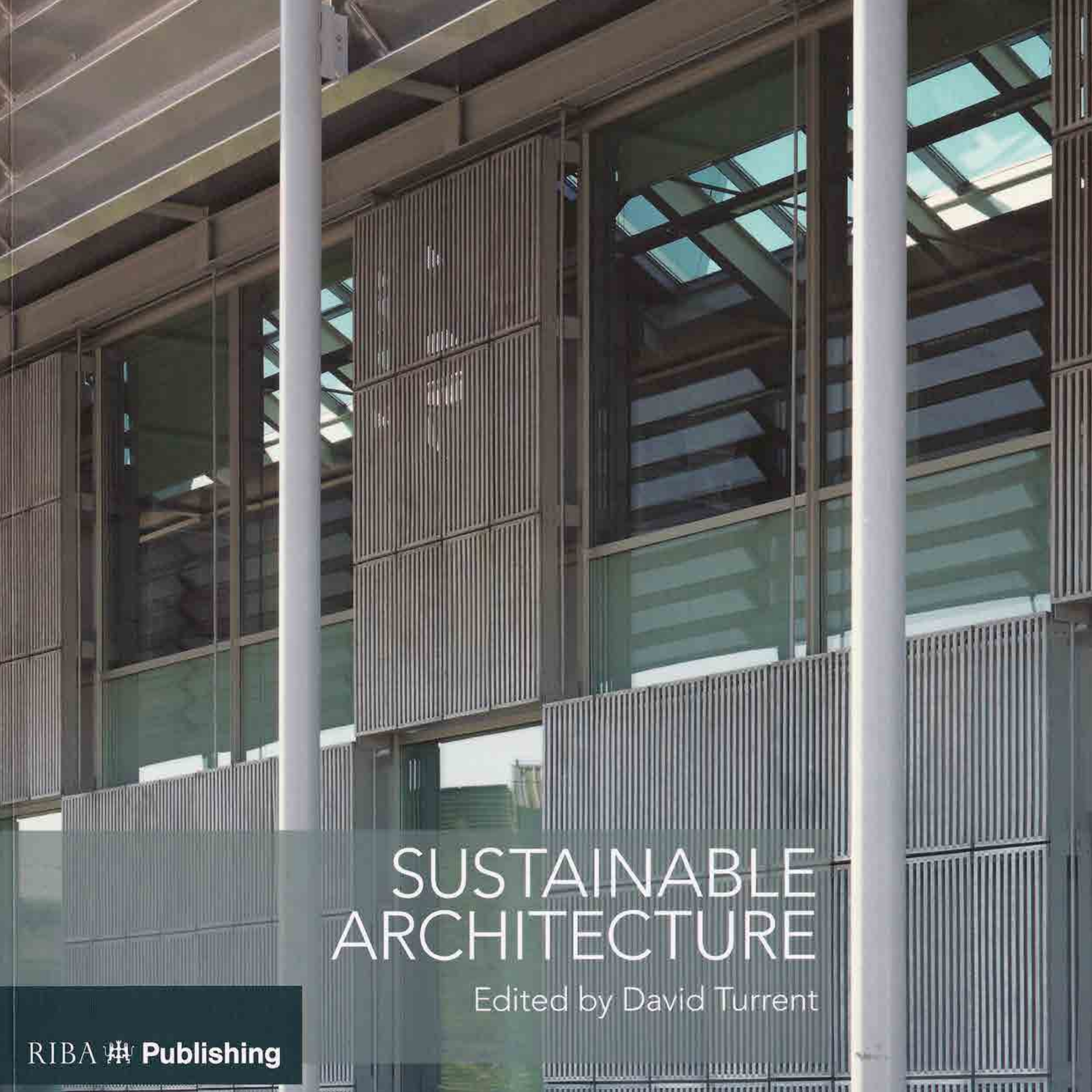


SUSTAINABLE ARCHITECTURE

Edited by David Turrent

RIBA Publishing

Bill Taylor

1 WORK SPACES

Fig 2.01 Inland Revenue, Nottingham

THE ARUP CAMPUS, Solihull
TECHNIUM OpTIC, St Asaph
WESSEX WATER OPERATIONS CENTRE, Bath
CEME, Rainham
EDEN FOUNDATION BUILDING, St Austell
HEELIS, THE NATIONAL TRUST HQ, Swindon
SOUTH CAMBS DISTRICT OFFICES, Cambridge
ENVIRONMENT AGENCY, Wallingford

INTRODUCTION

First some figures from the Department of Trade and Industry.[1] In 2005 construction output in the UK on new buildings in the commercial sector (offices and industrial workplaces) was £20 billion. Annual CO_2 emissions from commercial buildings account for 12% of the UK total. When it comes to using resources in their making and their operation, offices, factories and shops are clearly hungry and expensive beasts.

Much has been written about the benefits to business of procuring more sustainable buildings, but there is little factual evidence to back this up. It is a commonly held belief that sustainability adds capital cost but even here opinions are divided. The Building Research Establishment (BRE) estimates that over a typical 60-year life, the costs of operating an office building will be approximately five times the initial construction costs, while over the same period the costs for the staff are likely to account for approximately 200 times the initial outlay.[2]

To owners and occupiers these represent the major costs of their investment and a growing number of organisations are recognising the real benefits not only of reducing running costs, but of more efficient resource utilisation, increased productivity, recruitment, retention of staff and the major public relations benefits that are derived from what we have come to call 'sustainable' developments.

Over the last 20 years or so, architects and engineers have demonstrated that environmentally responsible office buildings can be achieved. Large projects such as Gateway 2 in Basingstoke (Arup Associates) and the Inland Revenue, Nottingham (Michael Hopkins and Partners), which was the UK's first BREEAM Excellent rated project,[3] showed that long life, flexible, well lit, efficient and cost-effective naturally ventilated offices for the late twentieth century could be achieved.

These and other similar buildings utilised the inherent characteristics of site, built form and materials to good effect. Relatively simple and straightforward in their construction and operation, they provided a benchmark, a starting point from which we could advance. The basic techniques involved:

- sensible orientation of the buildings which responded to the specifics of the site
- opening windows and local controls with supplementary displacement ventilation
- floor plate depths of 12–14m
- façades that controlled solar gain and heat loss through protection
- heavy mass structures exposed internally, which soaked up the heat of the day and were cooled at night
- high levels of insulation and airtightness
- low pressure drop ventilation systems.

Their performance was studied and disseminated. Although they performed well (e.g. 110kWh/m^2 at the Inland Revenue compared with ECON19[4] Best Practice 114kWh/m^2), they were limited by lack of heat reclamation systems and ineffective control systems, particularly for lighting. Notwithstanding their

1 Department for Trade and Industry/ Construction Statistics Office/Department for Business Enterprise & Regulatory Reform www.berr.gov.uk

2 Sustainable Buildings: Benefits for Occupiers (BRE) publication IP13/03 Part 1, 2003 by Alan Yates

3 BREEAM Excellent rated project: Highest rating obtainable from BREEAM (Building Research Establishment's Environmental Assessment Method), the world's longest established and most widely used environmental assessment method for buildings. It sets the standard for best practice in sustainable development

4 Energy Consumption Guide 19 (ECON 019) was first published by the Building Research Establishment (BRE) as part of the Energy Efficiency Best Practice programme. It sets out 'typical' and 'good practice' energy consumption benchmarks for four office types; naturally ventilated cellular, naturally ventilated open plan, air conditioned standard and air conditioned prestige. It was introduced in 1991 and updated in 1995. In 2001 it was taken over by the Carbon Trust and the reference changed to ECG 019.

5 BCO, *Best Practice in the Specification for Offices*, British Council of Offices: London; 2005.

6 K Puckett & C Stocks, Jolly Green Giants, *Building* magazine; 21st July 2006.

environmental credentials, these projects were seen as 'good architecture' setting new standards in office accommodation and winning major awards. We have now moved beyond these exemplars to a more sophisticated generation of projects, often incorporating active systems:

- mixed mode ventilation systems with energy reclaim systems
- use of on-site renewables such as ground water, solar water heating, photovoltaics (PV) wind-assisted ventilation
- evaporative or mechanical cooling for peak temperature lopping
- control systems that respond to seasonal as well as diurnal variations
- water management strategies
- integration of buildings into a wider biodiverse site environment.

Sustainable working environments are, of course, about far more than the performance of the building fabric. How the building is used is of at least equal importance. Changing and new methods of work, the increase in remote outreach networks, the virtual office as well as space utilisation, efficiency of planning, the exploitation of new technologies – all will bring influence to bear on the efficiency of the 'building as a machine', if indeed a building is needed at all.

This chapter, however, focuses on the 'hardware' of the working environment – buildings. The case studies illustrated in this section come from both public and private sectors. They are exemplars of a commitment by both a client and team to creating humane, socially inclusive and environmentally responsible buildings. They are by definition commercial; built to realistic budgets and timescales, for real (mostly end user) clients. But how is the mainstream commercial speculative market performing? In the British Council for Offices (BCO) *Best Practice in the Specification of Offices*,[5] 'sustainability' is a constant thread connecting all aspects of the office developers' design world. The BCO document is a reasonable attempt at establishing an industry attitude and although it declines to identify quantitative targets, it does attempt to set out a balanced approach to the issue.

Before writing this section I invited the UK's major developers to nominate built projects they felt represented exemplars of truly sustainable speculative commercial developments. Sadly, but maybe not surprisingly, there were few responses and no convincing nominations.

In July 2006 Building magazine[6] conducted a survey of 50 large client bodies asking how much of their total construction budget was spent on sustainability. Topping the 'total spent' column was Land Securities, the only private developer listed, claiming an expenditure on sustainability of 2%. This compared with 6% by Asda Stores and 19% by University College, London. Difficult to particularise and compare – undoubtedly; a snapshot in time – of course, but still it would seem it is the public sector that is leading the way.

THE ARUP CAMPUS

The Arup Campus in Solihull accommodates 600 staff in three deep plan linked pavilions on the edge of an SSSI. The buildings achieved a BREEAM Very Good rating for Phase 1 and a detailed post-occupancy survey was completed in 2004.

Located on the edge of a Site of Special Scientific Interest (SSSI), the Arup Campus consists of three two-storey office pavilions linked with a central core block. The gross internal floor area is 9,058m² (total Phases 1+2). The brief from Arup, a global engineering company, was to create an office with a sense of openness, both internally and to the surrounding landscape. The building should be an integrated sustainable design solution delivered for a budget equivalent to that for a standard business park office.

The building responds to the site topography with a split section, modulating the relative height of the three pavilions and providing 24m deep office space. The pavilions each have a series of central and perimeter voids allowing air circulated by stack effect to be exhausted via roof-mounted chimneys. The structure is an expressed steel frame with pre-cast concrete floor planks providing thermal mass. The building is naturally ventilated with a mix of automatic louvres controlled by the building management system (BMS) and manually opening windows. Minimum fresh air in the winter and summer night-time cooling are achieved. Server rooms and lecture theatres are provided with mechanical ventilation and cooling. Heating is provided by a conventional low-temperature hot water (LTHW) radiator system. The façades are of cedar, which, with the roof cowls, provide an aesthetic response to the rural setting. The substantially glazed façades facing south-east are protected by external BMS-controlled solar radiation-linked motorised blinds and shutters. Manually operated internal blinds are also provided for other façades, and external timber shutters are provided to screen the façade facing the car park. Daylight-linked dimmable artificial lighting provides 350 lux maintained luminance in the office spaces.

Address	The Arup Campus Blythe Gate Blythe Valley Park Solihull B90 8AE
Construction Cost	Phase 1 Construction value: £7.3 million Phase 2 Construction value: £6.5 million
Completion Date	Phase 1 February 2001
Client	Prologis (Phase 1); British Land (Phase 2)
Tenant	Arup
Architect	Arup Associates
Quantity Surveyor	Arup Associates and Faithful and Gould
Structural Engineer	Arup Associates
Services Engineer	Arup Associates
Main Contractor	Interserve (Phase 1); Laser Build (Phase 2)
Landscape Architect	Roger Griffiths Associates (Phase 1); Edco Design (Phase 2)

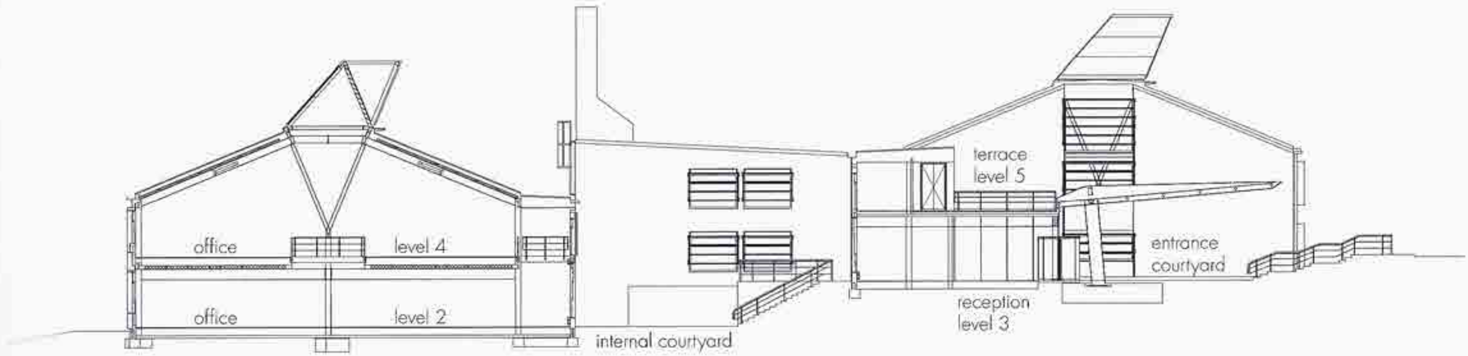
2.02

Fig 2.02 Elevational detail showing external timber shutters
Fig 2.03 Internal view, first floor
Fig 2.04 General external view
Fig 2.05 Site section

2.04

In 2004, Phase 1 was monitored in occupation. Peak summertime internal temperatures were 1–2 degrees below that of the external temperature. Annual gas consumption for space heating loads was 76kWh/m² as against 151kWh/m², the typical rating for a naturally ventilated office in ECON 19. The annual electrical total, however, was 167kWh/m², which is above the 87kWh/m² typical value in ECON 19. Of this, about 50kWh/m² was attributable to the data processing centre, café, external lighting and miscellaneous equipment not included in the ECON 19 benchmark. For the rest, the main areas of poor performance were lighting (44kWh/m²) and small power (47kWh/m²). Savings of 25–30% were identified which included conversion to LCD screens and occupants turning off unnecessary equipment.

On Phase 2 the design of the lighting control has been revised, which is expected to reduce electrical energy consumption by 30%. In conclusion, the buildings appear to perform well, they quietly express their environmental credentials and a post occupancy survey (*Post-occupancy evaluation case study – Advanced naturally ventilated office*, Alex Wilson and Barry Austin: Arup R&D; March 2004) has confirmed that user satisfaction and productivity are relatively high.



TECHNIUM OpTIC

The Technium centre carries out research and development in Optronics, including thin film photovoltaics, which are integrated in the south-facing sloping wall of the building, providing a peak output of 84kW.

Address	Technium OpTIC Ffordd William Morgan St Asaph Business Park St Asaph LL17 0JD
Construction Cost	£11.1 million
Completion Date	February 2004
Client	Department for Enterprise, Innovation and Networks, Welsh Assembly Government
Tenant	Optopreneurs Ltd
Architect	Capita Architecture
Quantity Surveyor	Bucknall Austin
Structural Engineer	URS Corporation
Main Contractor	Shepherd Construction Ltd
Sustainability Advisor	URS Corporation

Set in a business park, this building links university centres of excellence with entrepreneurial business such as Optronics, which combines the properties of optical materials with electronics, and is a key enabling technology of the 21st Century. OpTIC will be one of a number of Technium Centres promoting and supporting innovative technologies to generate new employment opportunities and stimulate the wider local economy. A nature reserve has been created within the business park to provide a natural habitat for a number of wildlife species, which were relocated under an approved Habitat Mitigation Scheme.

The main feature of the building is a 1000m^2 photovoltaic wall, Europe's largest Copper Indium Diselenide (CIS PV) installation, with a peak rating of 84kW, which screens the highly serviced technical facility – essentially a black box. The inclined wall also channels rainwater to the harvesting pond at its base for re-use in the building and external irrigation. An internal 'street' acts as a buffer and circulation spine. This street enjoys a light, airy environment due to its overall height and its glazed roof, and incorporates breakout spaces providing a place to relax and network. It also serves as a key component to the natural ventilation strategy drawing air through the street and back out through the vents located within the glazed roof over. The *Green Guide to Specification* (Building Research Establishment; 2005) was used as a basis for specifying materials. Off-site fabrication of components was also employed to increase quality and reduce waste. Further uses of waste and sustainable materials included recycled hardcore, topsoil re-used on the site, modified terrazzo with glass as aggregate, as well as feature walls and paving constructed out of recycled waste slate.

Other features include: PV external lighting units, low-energy cooling, natural ventilation and low-energy displacement ventilation. Insulation values are 15% better than 2002 Building Regulations standard and a BMS system optimises heating, cooling and ventilation systems. Low-energy lighting includes daylight and presence sensors. Water conservation measures include: spray taps, showers

2.06

Fig 2.06 Internal street
Fig 2.07 South façade showing PV wall
Fig 2.08 General view showing offices and production facility

with low-flow heads, and rainwater harvesting with tank storage of 40,000 litres, and a reflection pond reservoir at the base of PV wall. The rainwater harvesting anticipates a saving of 1000m³ of water per annum.

During the design and delivery process, sustainability workshops were held to set objectives and derive solutions in most aspects of the project, backed up by research into the costs and benefits of the various materials, components and systems being considered. To facilitate the OpTIC and other developments on the St Asaph Business Park, a nature reserve had to be created within the business park to provide a natural habitat for a number of wildlife species, which were relocated under an approved Habitat Mitigation Scheme. The project is testament to an informed client and a committed project team. Its importance lies beyond the purely environmental and is a statement of optimism in the future. The photovoltaic installation has been monitored as part of the DTI Major PV Demonstration Programme to provide analysis of the running and energy costs. The metered output of the system has averaged 64,250kWh per year, equivalent to approximately 27 tonnes of CO_2.

WESSEX WATER OPERATIONS CENTRE

Completed in July 2000, Wessex Water addresses a wide range of issues including energy efficiency, water conservation, integration with landscape and community involvement.

Address	Wessex Water Services Ltd Operations Centre Claverton Down Road Claverton Down, Bath BA2 7WW
Construction Cost	£22.5 million
Completion Date	July 2000
Client	Wessex Water
Architect	Bennetts Associates
Quantity Surveyor	Davis Langdon
Structural Engineer	Buro Happold
Services Engineer	Buro Happold
Landscape Architect	Bernard Ede/Grant Associates
Project Manager	Buro Four Project Services
Construction Manager	MACE
Sustainability Consultant	BRE

The operations centre was part of Wessex Water's long-term plan to rationalise five separate buildings into a centralised facility for 580 staff on the site of a demolished isolation hospital, and on the edge of a designated area of outstanding natural beauty (AONB). The building was required to be an exemplar of environmentally sensitive architecture with an estimated annual energy consumption of 53kWh/m^2 of gas and 47kWh/m^2 of electricity, about two-thirds of the then current best practice value for a naturally ventilated office and far less than the norm for headquarters buildings.

The 10,000m^2 building adopts a low profile. Most of the office accommodation is in three uniform wings that adopt an E-shape on plan, each wing facing south and looking over the roof of the one below. In between the offices and the communal areas is a top-lit, linear space that becomes narrower as it descends the contours from the main entrance to the woodland at the foot of the site. This forum-like space is the mechanism for binding the disparate parts of the building together and is the location for impromptu meetings, social gatherings and special events.

A north–south orientation, thermal mass, solar shading, natural cross-ventilation wherever possible and minimal mechanical ventilation were all employed to minimise energy consumption and the need for artificial cooling. Night cooling of the offices via BMS-controlled high-level windows reduces energy consumption further. Solar water heating reduces operational energy consumption. Minimising the volume of materials reduced energy used for construction. The precast exposed concrete coffer system provides the required thermal mass to cool the building. The design team also specified materials with low CO_2 emissions in manufacture. Locally supplied materials were used to minimise transport emissions. Off-site prefabrication and quality inspections reduced on-site waste to a minimum. Thereafter, it was sorted and 70% was recycled to avoid landfill tax with a net financial credit of £15,000 to the project.

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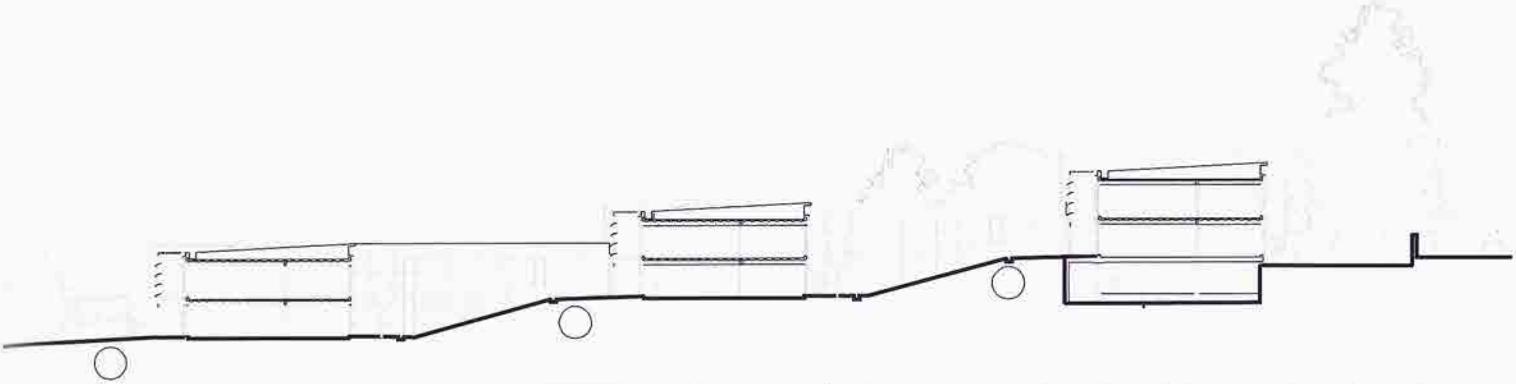

Fig 2.09 The building integrated with the landscape
Fig 2.10 Site section
Fig 2.11 Internal view

Rainwater and surface water are collected in holding tanks buried beneath landscaped areas, with grey water used for irrigation and 95% of toilet flushes. Porous paviors in the car park allow surface water to percolate off into the natural water table instead of local sewers. The landscape strategy reinforced the existing flora and fauna and encourages local wildlife.

Buro Happold was commissioned by Wessex Water to report on energy consumption, water consumption and internal environmental performance. Their monitoring commission was initially for three years, commencing in Summer 2001.

Adjusted energy use for Wessex Water HQ's first three years is summarised below and compared with predicted figures (using ECON 19 conversion factors of 0.19 $kgCO_2$/kWh of gas, 0.52 kg CO_2/kWh of mains electricity and based on a treated floor area of 9360m²).

	Electricity kWh/sq m²/yr	Gas kWh/sq m²/yr	Total carbon dioxide emissions $kgCO_2$/sq m²/yr	Water l/person/day
Scheme design target	47	53	35	45
Adjusted consumption year 1	62	73	46	n/a
Adjusted consumption year 2	55	66	41	n/a
Adjusted consumption year 3 (CO_2 saved by using green electricity tariff)	52	45	36	26
Good Practice	57	80	45	n/a

CEME

The Centre for Engineering & Manufacturing Excellence (CEME) in Rainham, Essex, is a centre for education, enterprise and manufacture built on a former waste dumping ground donated by Ford. It is planned around a 150m south-facing street and incorporates a 100kW^peak photovoltaic array and a wind turbine.

Address	CEME Campus Marsh Way Rainham Essex RM13 8EW
Construction Cost	£20 million
Completion Date	December 2003
Client	Centre for Engineering and Manufacturing Excellence
Architect	Sheppard Robson
Project Manager and Quantity Surveyor	Faithful & Gould
Structural Engineer	Campbell Reith Hill
Services Engineer	Whitbybird
Main Contractor	SDC Construction Group
Landscape Architect	Lovejoy

CEME is the flagship project for the Thames Gateway strategy for the regeneration of the east London corridor and the improvement of opportunities for local people. Investment in the project came from a public/private partnership including the Ford Motor Company, the London Development Agency, Barking and Havering Colleges, the European Regional Development Fund, the DTI and the Single Regeneration Fund. The brief called for an iconic exemplar of sustainable development.

Located adjacent to the A13 trunk road, CEME has been designed as a building integrated into the industrial surroundings of the site. The glazed north elevation offers passers-by views of the processes and activities within the large workshop areas. A protruding auditorium dominates the business studies workshop offering a 'Harvard' model lecture theatre. A long curved spine also acts as the structural and services backbone to the building. To the south of the spine sits the 'street', a 150m-long circulation zone for the students, teachers and drop-in users, with information points and IT hot-desking areas, a restaurant and coffee points. The southern elevations beyond the street open out onto a continuous timber deck, overlooking a landscaped area, lake and outdoor amphitheatre.

Low-energy design has been incorporated throughout the building. Photovoltaics have been incorporated to provide an integrated roof solution to the canopy and

2.12

the street. The team successfully secured £357,000 funding for this system through the DTI Major PV Demonstration Programme and the European Commission. Natural ventilation to the street and workshop areas, together with daylight sensitive lighting controls further reduce the energy requirements of the building.

Other notable innovations include:

- Waste minimisation – constructed by the contractor using BRE SmartWaste procedures. Comprehensive strategy for building in use to reduce land fill waste.
- Bio-diverse landscape – designed in consultation with the Environment Agency to improve habitat for water voles, newts and incorporating a lake to take surface water run-off from hard landscape areas.
- Energy and water efficiency – the largest integrated photovoltaic roof array by output in UK on completion. Rainwater recycling reduces consumption of potable water. Low-energy lighting/controls. Natural ventilation. Low level air displacement with heat recovery.
- Re-use of brownfield site with limited commercial value in previous state (former Ford waste dumping ground), now catalyst for socio-economic regeneration of area.
- Minimising traffic/use of car – a green travel plan incorporating cycle network and 24-month subsidised public transport to discourage habitual use of private vehicles.

Social interaction between the occupants lies at the heart of this scheme, and the dialogue between internal and external spaces reinforces the environmental message to the users. The 100kW^{peak} array contributes 15% of the site electricity requirements, approximately 60,000kWh per year (equivalent to 25 tonnes of CO_2). The incorporation of the PV arrays, while a major funding success, does illustrate one of the challenges of renewable energy sources, namely the successful integration of such components into an holistic architectural expression.

Further information: www.ceme.co.uk

Fig 2.12 Solar roofscape
Fig 2.13 External view at night
Fig 2.14 Internal street

EDEN FOUNDATION BUILDING

The Eden Project is a renowned and popular visitor attraction and the new Foundation Building[1] provides a comfortable working environment over two floors for the project's staff. The building demonstrates respect for its environment and meets high sustainability targets, receiving a BREEAM rating of Excellent.

Address	Eden Project Bodelva St Austell Cornwall PL24 2SG
Construction Cost	£ 2.5 million
Completion Date	December 2002
Client	The Eden Project Ltd
Architect	Grimshaw
Quantity Surveyor and Project Manager	Davis Langdon
Structural Engineer	Anthony Hunt Associates
Services Engineer	BDSP
Construction Manager	McAlpine Joint Venture

The 1800m² building, set at the edge of an old quarry, provides a comfortable working environment for the Eden Project administrative team and library facilities for a partner organisation, Cornwall College. The Foundation Building is created from materials sourced from sustainable suppliers, appropriate for a client with an inspiring ecological mission.

The Foundation Building is laid out over two floors on a 6m x 14m primary grid. Large modular bays run the length of the building from north to south. Floors are arranged around a central open staircase and are largely open plan, with partitioned offices on the east side of the ground floor and meeting rooms located to the north end of the first floor. The central roof lantern running the length of the building provides natural lighting and cross-ventilation. Daylight and air travel down from first to ground floor through a series of voids. Timber-decked external terraces at ground and first floor level and a projecting curved balcony extend out beyond the building envelope. Instead of the traditional flat floor slab, the building is raised off the ground, supported on timber columns bolted to concrete pads that support a suspended timber floor structure. During construction, this minimised the volume of soil to be removed from the site and also reduced the amount of cement needed. The columns are as slender as possible, having the absolute minimum cross-sections for structural efficiency. The building skin is breathable, extremely lightweight and well insulated with a 241mm deep Warmcel™ (recycled

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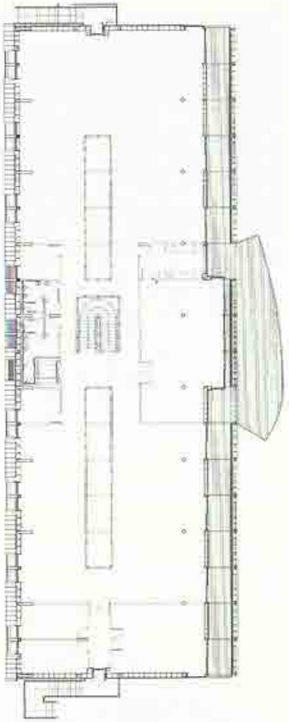
Fig 2.15 General view of the Foundation building
Fig 2.16 First floor plan
Fig 2.17 Section



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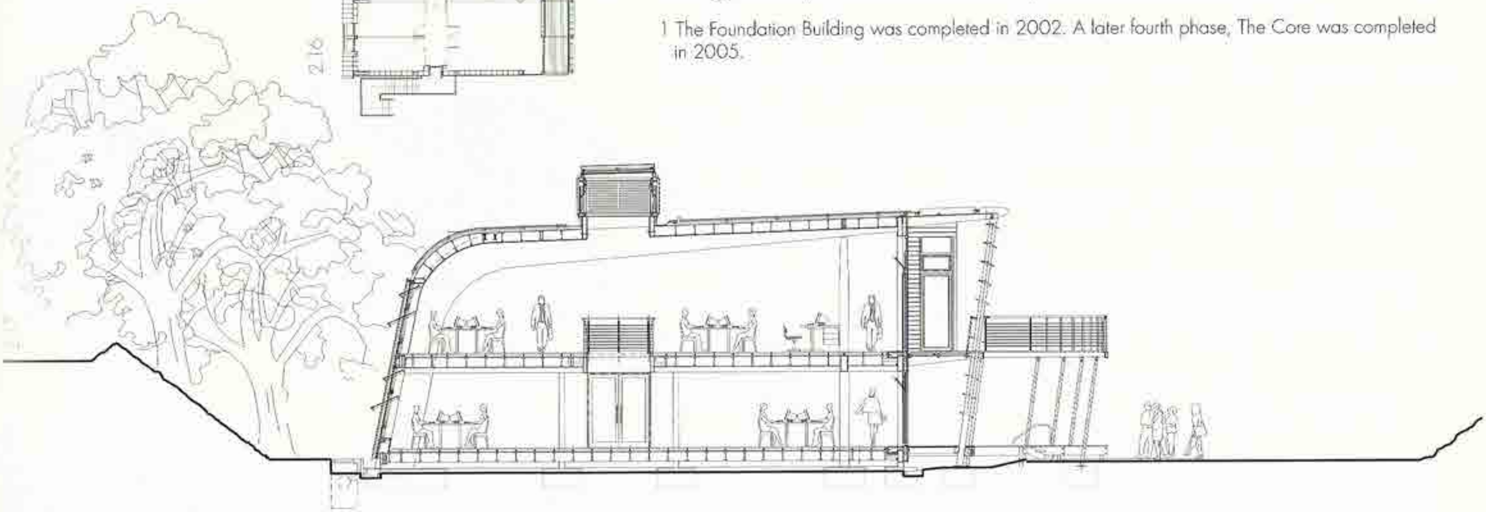
newsprint) filled cavity for floor, wall and roof achieving a U-value of 0.13W/m²K. The lightweight structural timber frame is sourced from certified renewable sources. The west façade is timber clad with Canadian Western Red Cedar, selected because it weathers well, has natural durability and does not need to be treated with weather resistant coatings or preservatives. Lightweight perforated aluminium louvres protect the large timber-framed double-glazed windows on the west elevation, reducing solar impact on the interior of the building while maintaining daylight and allowing views across the site. The materials chosen and use of prefabrication result in a building that was erected with ease and speed and avoided the need for large cranes.

The annual heating energy consumption, including domestic hot water, accounts for some 30kWh/m², lower than expected. However, at 86kWh/m², annual electrical energy consumption was much higher. Server rooms, catering and external lighting accounted for approximately 25% of this. The rest of the high energy use was attributable (again) to problems with the automatic lighting controls and office equipment, which could be turned off more. The Foundation Building proves that the requirements of economically viable, high-occupancy office buildings need not be at odds with the sustainable ideal and was the first building to have been completed by the architects using their own environmental management system – Environmentally Viable Architecture (EVA).

1 The Foundation Building was completed in 2002. A later fourth phase, The Core was completed in 2005.



HEELIS, THE NATIONAL TRUST HQ

This new headquarters building for the UK's largest charity provides a highly sustainable workplace and demonstrates that significant improvements can be achieved over the performance of typical commercial buildings built to similar budgets. Winner of the RIBA Sustainability Award 2006.

Address	Heelis Churchward Park Kemble Drive Swindon SN2 2NA
Construction Cost	£14.5 million
Completion Date	June 2005
Client	The National Trust
Architect	Feilden Clegg Bradley Architects LLP
Quantity Surveyor	Davis Langdon
Structural Engineer	Adams Kara Taylor
Services Engineer	Max Fordham and Partners LLP
Main Contractor	Moss Construction
Project Manager	Buro Four Project Services

The relocation of the central administration functions of the National Trust brought together 470 staff under one roof for the first time as part of the process of honing the organisation for the new millennium. Sustainability is at the heart of the National Trust's mission and the project brief was to develop the most sustainable building possible within the available budget. Heelis is a two-storey, open plan building which provides 7110m² of office space, meeting rooms and workshops plus a shop and café. The project received a BREEAM Excellent rating.

The deep plan two-storey building comprises a first floor punctured with a series of voids which connect the two levels and allow daylight to reach the ground floor. The concept synthesises the line of the adjacent railway sheds with solar geometry to generate roof pitches facing due north/south. The roof provides large areas of carefully shaded north lighting and incorporates ventilation 'snouts', which enhance natural ventilation with air intake via motorised panels in the elevations. Densely occupied internal spaces are mechanically ventilated with comfort cooling using 'Earthcare' propane chillers. Internally an average daylight factor of 5% and a fully dimmable lighting system reduces the use of artificial lighting. Concrete soffits at both levels provide extra thermal mass, which, combined with night ventilation, help to absorb heat during the day and create a comfortable environment without artificial cooling. A mechanical ventilation system with heat recovery helps to limit heat loss in winter. A roof-mounted photovoltaic installation funded with a 65% grant from the DTI is rated at $83kW^{peak}$ and is predicted to provide 30% of the annual electrical consumption. Externally, the elevations combine engineering brick laid in lime mortar with cast aluminium panels (using 92% recycled aluminium and cast in nearby Melksham) combining low maintenance with recyclability. The

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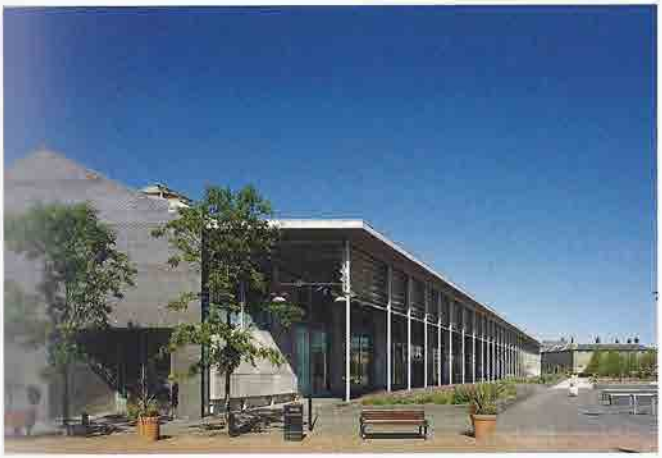
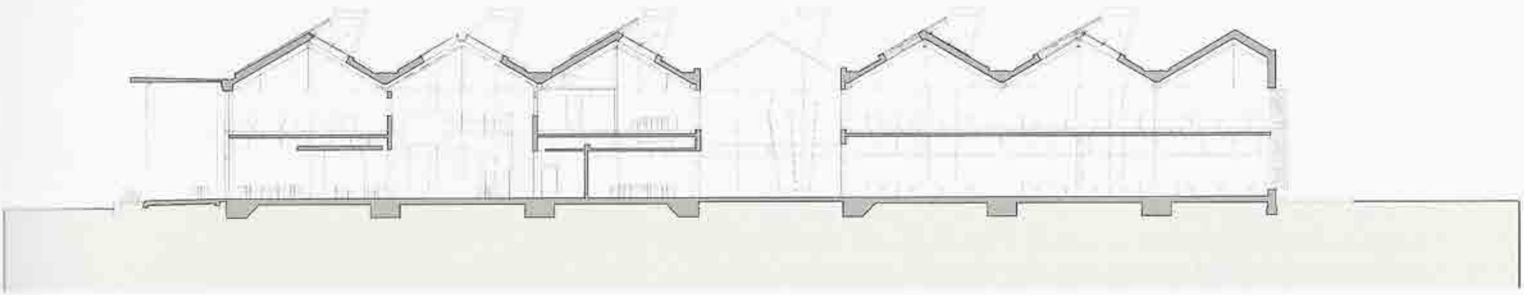


442mm-thick external wall construction has a U-value of 0.2W/m²K. Care has been taken to shade all glazing to eliminate solar gains using projecting brick fins, perforated aluminium screens and cantilevered PVs to protect the rooflights. Internally, timber from National Trust estates has been used in the central atrium wall linings, and furniture was manufactured in Berkshire. Wool from Herdwick Lakeland sheep has been used in carpet tiles developed for the scheme.

The landscape around the building uses native species typical of post-industrial sites. The courtyards provide private amenity space for staff and are landscaped to maximise seasonal variety. This new headquarters building provides a distinctive and highly sustainable workplace, and demonstrates that significant improvements can be achieved over the performance of typical commercial buildings built to similar budgets. The deep plan building has been designed to provide an excellent working environment and to minimise energy usage. It is estimated that CO_2 emissions will be reduced by 65% compared to best practice benchmarks (ECON 19), to less than $20kgCO_2/m^2/yr$. Eighteen months after completion, post-occupancy feedback is that the building is meeting its energy and temperature targets and NT staff clearly love their new HQ.

Fig 2.18 Internal view showing natural lighting
Fig 2.19 General view of shaded south facade
Fig 2.20 South elevation at night
Fig 2.21 Typical section



SOUTH CAMBS DISTRICT OFFICES

This new Town Hall for South Cambridgeshire, which was built as a joint venture between public and private sectors, achieved a BREEAM Excellent rating.

Address	South Cambridgeshire Hall Cambourne Business Park Cambourne Cambridge CB3 6EA
Construction Cost	£10.5 million
Completion Date	April 2004
Client	South Cambridgeshire District Council
Architect	Aukett Fitzroy Robinson
Quantity Surveyor	AYH
Structural Engineer	Whitbybird
Services Engineer	Faber Maunsell AECOM
Main Contractor	Alfred McAlpine Special Projects
Landscape Architect	Aukett Fitzroy Robinson
Developer	Development Securities/Wrenbridge Land

The building provides headquarter facilities for South Cambridgeshire District Council (SCDC) and comprises council chamber, committee and meeting rooms and general office accommodation for the various departments of the council. SCDC was previously located in cramped, outmoded offices in central Cambridge. The council decided to site their new HQ at the heart of their constituency and within the newly formed village of Cambourne, a new growth area to the west of Cambridge City. The brief evolved to create a building which was inviting and accessible both visually and physically to the public, and which embraced a more open-plan office culture; a major transformation from a previously highly cellular culture at the city location. The brief also stipulated that the design should embrace energy-efficient, low-carbon strategies, and targets for reductions in running costs and replacement costs.

Initially, the design process commenced with a competitive bid and design proposal to secure the council at Development Securities' Cambourne site. The brief was in its infancy at this stage and Aukett Fitzroy Robinson's design recommended three key design strategies:

- low-energy concepts including mixed mode ventilation with heat reclamation and night-time cooling
- open-plan culture for the main office environment
- an open visual and physical environment to reflect a more open interface with the public and the council's constituents, while still permitting a naturally ventilated strategy.

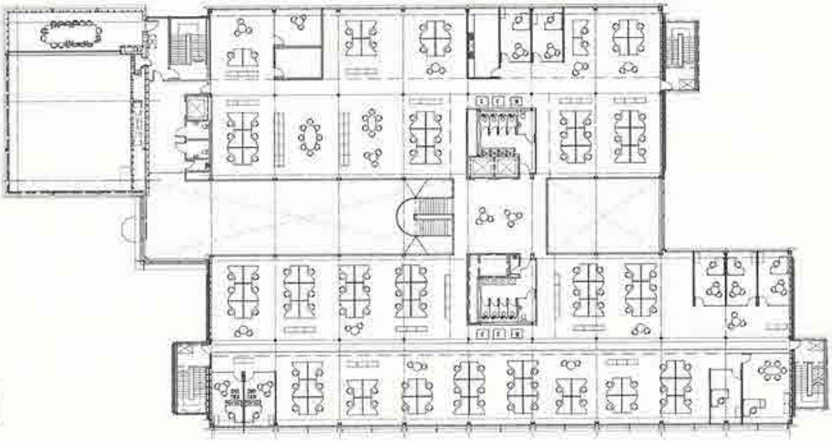
Three storey 15m wide floor plates allow for natural cross-venting by openable windows. The central street is covered by ethylene tetrafluoroethylene (ETFE), which permits daylight to penetrate the internal zones of the floor plates, and the street space is used as the exhaust air plenum. Lightweight steel columns and beams support exposed precast concrete floor and roof slabs and night-time cooling is achieved.

2.22

Rainwater is collected and used for WC flushing and there is also solar water heating. Annual energy targets were 62kWh/m² of electricity and 65kWh/m² of gas. As the building was to be procured via a 'turn key' design-and-build contract between the developer, contractor and council, the design development stages involved detailed cost appraisals to evaluate construction costs set against energy consumption reductions.

Post-completion, the building has been monitored to assess thermal performance, which has led to limited fine tuning of the building management system (BMS), and adjustments to the automated louvre system on the east elevation to optimise solar control and internal environment. However, no measured data was available at the time of writing.

It is rare to find both a speculative office development and a building for a local authority that takes account of sustainability. However, this project is an exemplar of how, through collaboration, both sectors can realise their mutual goals and as such it offers a number of lessons for both sectors. The project embraced extensive end-user consultation and involvement throughout the design and construction process and has succeeded in blending commercial and environmental viability for the mutual benefit of both. Estimated CO_2 emissions are $45kgCO_2/m^2/yr$ at ECON 19 values.



2.24

Fig 2.22 General view at night
Fig 2.23 Internal street with ETFE roof
Fig 2.24 Typical floor plan

ENVIRONMENT AGENCY

Designed to be an example of best practice in sustainable office development, this naturally ventilated, concrete-framed building achieved a BREEAM Excellent rating with predicted carbon emissions 26% below ECON 19 guidelines.

Address	Red Kite House Howbery Park Benson Lane Wallingford Oxfordshire OX10 8BD
Construction Cost	£ 4.5 million
Completion Date	February 2005
Client	The Environment Agency
Architect	Scott Brownrigg
Quantity Surveyor	Davis Langdon
Structural Engineer	Waterman Partners
Services Engineer	Hoare Lea
Main Contractor	Moss Construction
Landscape Architect	Whitelaw Turkington
Project Manager	Buro Four Project Services
Developer	HR Wallingford

Red Kite House is a new office for the Environment Agency. The 2788m² building is curved in plan and forms the gateway into a new business park – a quiet site incorporating an historic manor house. The agreed aim was to construct an office that would not only meet the Environment Agency's operational needs but would also serve as an example of best practice in sustainable office development. A key feature and requirement of the brief was to design a building that is environmentally friendly, naturally ventilated with an Excellent BREEAM rating. The following elements were significant in responding to the constraints and opportunities of the site:

- By orientating the building east–west it is possible to control the solar gain along the southernmost façade using roof-mounted louvres affording shading and providing a glazing system that allows only 40% clear glass.
- Sunlit spaces are created around the building and access can be gained to this landscape for occupants of the building at ground level.
- The short sides of the building that attract the early morning and late afternoon sun are minimised by the orientation.
- The north facing façade is more open to daylight with 60% clear glazing set within brick panels.

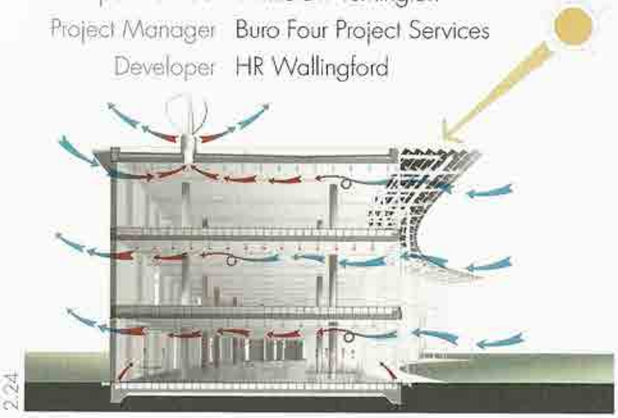


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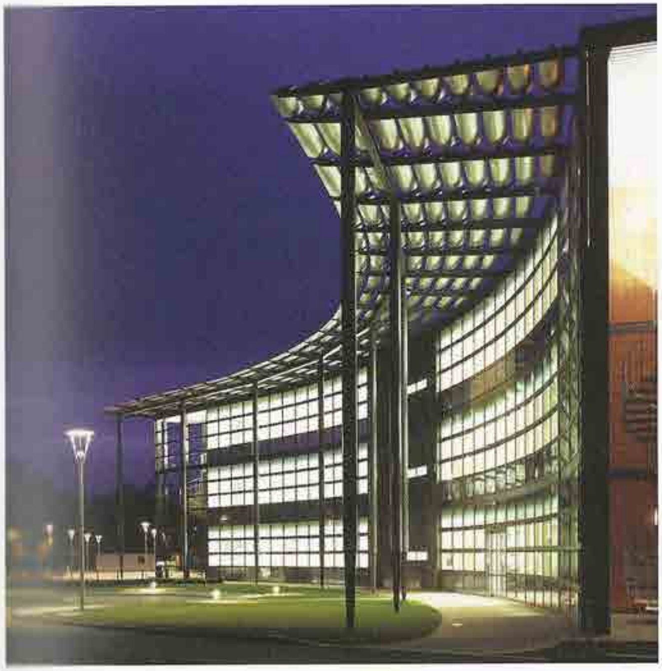
Fig 2.25 Typical section illustrating air flows
Fig 2.26 South elevation at night
Fig 2.27 General view showing solar shading



- Wind-assisted ventilation to the top floor through extraction fans provides air movement for the occupants on the top floor and accelerates cooling of the structure.
- The building is naturally ventilated with low-level manual opening windows and high-level BMS-controlled clerestory lights.
- Exposed concrete structure internally for thermal mass and night cooling.

Environmental features:

- 200m² of photovoltaic cells are predicted to generate 20,000kWh of electricity per year, or about 20% of the building's estimated requirement. This will reduce the amount of carbon dioxide discharged to the atmosphere by about 12 tonnes per year. The cells clad the south-facing brise soleil, which projects about 3m from the roof at the front of the building and shades the interior.
- Solar panels on the roof satisfy about 40% of the demand for hot water. They reduce carbon dioxide emissions by a further 1.6 tonnes per year.
- The rainwater harvesting system collects rainwater from the roof which is held in an 8000 litre tank and pumped through filters for toilet flushing. It will satisfy about 40% of the total demand for water. Overspill is directed into a reed bed.
- Sustainable drainage from the car park allows rainwater to soak into the ground, while non-permeable areas will drain to a reed bed. A geotextile membrane traps oil and other pollutants and allows microbiological degradation to minimise risks of groundwater pollution.

The design strategy appears to have paid off. Internal temperature in July 2006 was 28°C while the external temperature was 34°C. Although there is no heat reclamation system, the use of on-site renewables has resulted in a meaningful reduction in carbon dioxide emissions for this relatively simple building. Estimated CO_2 emissions are $25.3kg/CO_2/m^2/yr$. A post-occupancy study is being carried out to optimise the energy consumption of the building and ensure that the targets are achieved.

SUMMARY

These case studies, most of which have achieved a BREEAM Excellent rating, illustrate how the world of the workplace can contribute to reducing CO_2 emissions while providing a visually stimulating environment and maintaining satisfactory comfort conditions. However, they also show that actual performance in use is not always in line with design predictions.

The principal areas of underperformance of the monitored projects relate to electrical energy consumption, particularly the use and control of artificial lighting and equipment by the occupants of the buildings. Given the high electrical demands of offices and factories, the use of on-site renewable energy sources is unlikely to be a key contributor to the occupancy loads, although it can meaningfully contribute to the building's base demand, especially when associated with other measures. Further exploitation of the wind to drive ventilation systems, the sun to naturally light our offices during the day and combined on-site electricity generation offers more scope.

Improved knowledge of actual (as opposed to predicted) performance is essential. Post-occupancy surveys of users and their productivity as well as systems must somehow be made to happen. While energy certification may eventually facilitate this, central and local government, as key procurers of sustainable projects must surely have a role to play in the funding of this work, which must then be disseminated.

The importance of an integrated supply chain for energy and buildings is being recognised. Locally sourced materials not only reduce transportation demands, but should result in more contextual solutions while at the same time injecting money and employment into local economies. This will inevitably extend beyond completion of the project into the whole life operation of the building in its use.

1 BCO, *Best Practice Guide: Energy Management in Offices*, London: British Council for Offices.

In their Summer 2006 Survey of Property Trends, GVA Grimley reported that some 76% of occupiers surveyed were prepared to pay 'marginally more' for an environmentally friendly building. The reported trend is that occupants are attaching a greater significance to the environmental credentials of the properties they use. It is not simply a matter of costs. Occupiers are also recognising other benefits such as increased staff productivity, satisfaction and improved company image. Even if a premium rent cannot be charged for this, it is likely that those properties that do not fulfil such occupant expectations, will, ultimately, be unable to command the same rental values as those that do. Given this, it is astonishing that the funders, developers and designers of commercial architecture in our country continue to fail to seize the opportunities to safeguard the longer-term value of their investments and to steal the edge from their competitors.

As experience demonstrates, there are a number of significant challenges to be surmounted in successful incorporation of systems and technologies into a holistic architectural solution. However, the body of exemplary sustainable projects continues to grow, albeit slowly, and this can only be encouraging.

The commercial sector has, at best, been slow to learn the lessons from the public sector and owner-occupiers and on the whole it has declined to implement them. More imagination is needed for mutually beneficial developments in order to overcome the short-term objections that invariably are put in the way. This must remain the urgent challenge for the future. It is never too late but, as Rab Bennetts in the BCO Guide[1] asserted, 'compulsion through regulation may be the only alternative'.