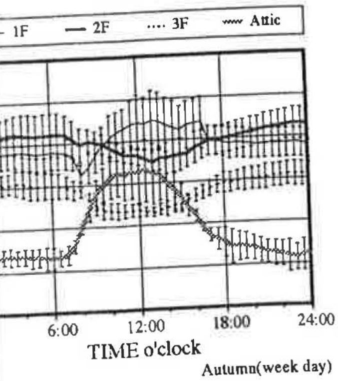

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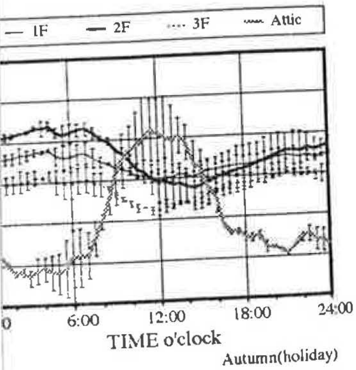

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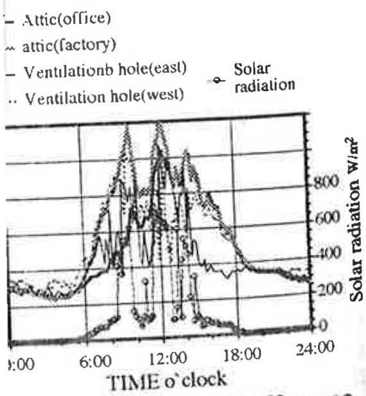

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THE QUEENS BUILDING FOR ANGLIA POLYTECHNIC UNIVERSITY

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ABSTRACT This is one of the first generation of Learning Resource Centres to be built at UK Universities. It provides 6000m^2 of accommodation including a library, 700 study spaces, TV studio, seminar rooms, offices and catering facilities. The building is designed to use natural ventilation rather than air conditioning, thus saving on energy costs and CO_2 emissions. Two central atria provide daylight to the centre of the building as well as a route for exhausting ventilation air utilizing the stack effect (the natural buoyancy effect of warm air rising.) The combination of exposed thermal mass internally and night time ventilation provides a means of 'free' cooling in summer. High performance triple glazed windows incorporate an upper section which opens automatically, controlled by the BEMS (Building Energy Management System) depending on internal/external temperatures. Twin light shelves are also built into the windows to reduce glare on VDU screens around the perimeter and to reflect daylight onto the ceiling. Low energy lighting is controlled to respond to daylight levels and provide background lighting to study areas, supplemented by individual task lights. All timber used is from certified sustainable sources. Natural materials have been used throughout e.g. stone, timber, linoleum. Results from the first year if monitoring show a 74% reduction in energy and 82% reduction in CO_2 emissions compared to an equivalent air conditioned building. Results from users surveys show that the light and airy qualities of the building are well liked and comfort conditions are good, even in the hot summer of 1995.

1. INTRODUCTION

The Queens building at APU is one of 8 projects in Europe being monitored under the THERMIE funded programme, Comfort 2000. Following a year of intensive monitoring and evaluation, the new Learning Resource Centre has been judged a success. Annual energy consumption has been measured at 113 kWh/m^2 representing a 74% saving compared to a typical air conditioned office. Reductions in CO_2 emissions are even more impressive achieving a saving of 82%. The design strategy for the building was developed in a memorable week long design workshop held in March 1993, attended by the whole design team as well as client representatives. The brief called for a 'gateway' building to the new campus, providing 6000m^2 of accommodation including a library, 700 study spaces, TV studio, media production, seminar rooms, offices and catering facilities.

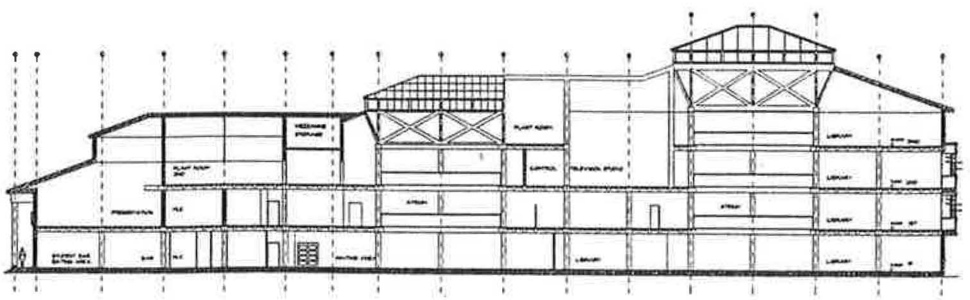
In addition the design had to comply with the University's energy policy, namely to:

- minimize the CO_2 emissions related to the construction and operation of new buildings
- minimize the related running costs
- minimize the maintenance burden of the campus
- help reduce the ozone layer depletion by the elimination of the use of CFC's/HCFC's or HFC's

Finally, the client presented the design team with the daunting challenge of delivering the building for occupation in October 1994, leaving only 18 months for design and construction. It was therefore not only a low energy project but also a fast track one and the building was completed on time and within budget.

During the design workshop, a strategy was evolved based on the following aims:

- avoid air conditioning
- use daylight efficiently
- utilize stack effect ventilation
- utilize high thermal mass
- use low energy lighting and sensitive controls
- install low NOx condensing gas boilers



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The building is located at th
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2. VENTILATION STR

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3. NIGHT COOLING

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4. DAYLIGHTING

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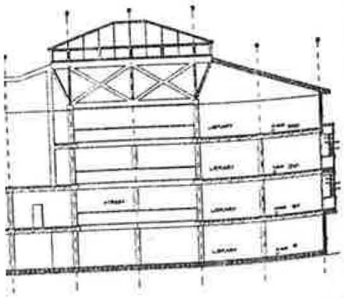


The building is located at the South West section of the site, addressing the route from the town centre. The four storeys of the main library respond to the massing of the adjacent 19th century mill. The building is planned around two glazed atria which are expressed in the roof form which steps down from four storeys to two at the north end, where a colonnade overlooks the river. Externally the materials are buff stock bricks enlivened with cast stone dressings and slate grey metalwork; natural slate covers the roof.

2. VENTILATION STRATEGY

Because the floor plan is relatively deep, at 30m, the ventilation strategy utilizes the atria to create a stack effect, drawing warm air from lower floors and exhausting it through opening vents at high level. Fresh air is introduced at the perimeter, through air bricks positioned below windows and through high level opening windows. The high level windows are controlled automatically by the BEMS, depending on internal/external temperatures, wind speed and direction. The air bricks at low level admit fresh air via the perimeter heating system so it can be pre-heated as required. These provide roughly 0.5 ach. Atrium vents are also controlled by CO_2 sensors and rain detectors. Obviously the stack height driving force is considerably greater on the lower floors than on the top floor. To avoid warm air flowing out through the top floor it is necessary to balance the air flow floor by floor. This is done by reducing the openable window area on each floor in proportion to the increased stack height.

3. NIGHT COOLING

Stack effect ventilation is capable of removing heat from the building for most of the year. During periods of peak outside temperature, supplementary cooling is provided at night by purging the structure of heat. The BEMS uses a self learning routine to decide when to open and close windows at night. It is important not to cool down the structure to such an extent that heating is needed the following morning.

4. DAYLIGHTING

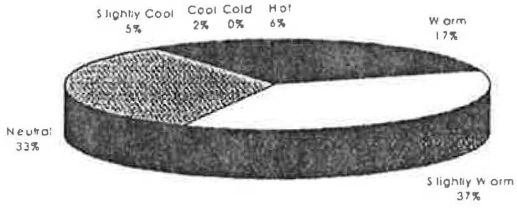
A great deal of effort at design stage went into the design of the window to optimise daylight penetration, minimize solar gain and control glare. As a rule of thumb a window area of around 45% of the total external wall area was used, with windows becoming smaller on the south and west facades. The typical window component measures 1 .95m high by 1 .8m wide and is triple glazed. The top section is an automatically opening horizontal pivot window. The bottom section has an integral blind for local solar control and is openable only for cleaning. The windows also incorporate twin light shelves internally which consist of mirrored glass to reflect daylight upwards onto the ceiling and cut out glare on VDU screens around the perimeter.

5. CLIENT/USER FEEDBACK

From a client's viewpoint APU regard the Queen's Building as a success.

- it was built on time and to budget
- it delivers the energy savings required
- it achieves a suitably pleasant environment

However, it is not perfect, but can any building claim that?



Perceived Thermal Comfort: Summer

From the users' viewpoint, both staff and students, the Queen's building must be regarded as a qualified success - as the results of the questionnaire survey carried out by APU's Building Performance Research Unit show. This survey was carried out with staff and students completing 100 detailed questionnaires over the period 18-29 July 1995 and 14-23 January 1996. The results indicate the occupiers response to the three fundamental design conditions of heating/cooling, day lighting and acoustics was reasonably good.

APU believe a lot can be learnt from this building in its conception, its construction process and its continued occupation. It has already been explained that the design approach and experience proved beneficial. Also lack of understanding by the Design and Build Contractor and/or the client was identified as potentially having major consequences in this "Passively designed" construction. Indeed the need for changes in space allocation which are now endemic in organisations will provide considerable challenge for the future to ensure performance is maintained.

Some 18 months after practical completion and 6 months after end of defects liability we still have a few contractual issues to resolve. One being the completion

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The BEMS is being used to
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of the contractors seasonal monitoring of the BEMS (which was waiting for the winter review period, as they missed the first) and another, the delivery of the "as built" drawings and maintenance manuals. The lack of these two items have not aided the operation or the understanding of the building's operation. From an operational viewpoint we must recognise that the BEMS "is not the answer to everything". However, it does assist in finding answers to problems by providing information, but you still require the intelligence to interpret this into the necessary action required and need the personnel to support this.

Due to the contractual position, the sophisticated control of the buildings environment and the local skill available, additional support was needed and delivered in the form of a maintenance contract, but this was unfortunately limited and remote from the operation. Fortunately the building is under the review of the EC in its THERMIE funded programme. We are also fortunate in that our own APU Building Performance Research Unit are carrying out the monitoring for ECD Energy and Environment the THERMIE Co-ordinators. A typical library floor (first floor) and the third floor, now used as office accommodation are now being monitored in detail. Generic performance data is also being gathered and analysed for the remaining building zones. In principle the following performance parameter are being assessed:-

1. Monthly thermal and electrical energy consumption
2. Annual passive solar gain
3. Measured overall building heat loss coefficient
4. Energy saving from the lighting and daylighting strategy
5. Incidence of over/under heating
6. Occupant responses
7. Any maintenance/implementation problems.

The BEMS is being used to record and download data concerning items 1-5 above. A dedicated analysis software package written by BPRU then processes and analyses the data automatically in the required form. It was intended that after the first year of monitoring and analysis the BEMS will be fine tuned to optimise the building's performance. This process of monitoring and calibration has proved invaluable in detecting malfunctioning components. An example of this concerns the night purging routine which was not occurring during the hot period in July/August 1995. After considerable investigation and numerous meetings it transpired that the controls sub-contractor had overridden this routine on the BEMS while carrying out repairs to a faulty activator. Unfortunately he failed to re-set the programme and several months passed before the fault was rectified.

The majority of internal air velocities yielded no meaningful results but were useful in identifying short circuits of air flow, for example from a compartment door at the north end of the building to air vents in the outside wall. Internal temperatures are very seasonally stable at the north end of the building, but towards the south exposed end they fluctuate about a seasonal mean.

A detailed user survey has also been conducted for both summer and winter conditions. In the summer the building was perceived as being consistently too warm and in the winter too dry. However, correlating between actual temperature and thermal response the internal conditions were not perceived as being greatly different despite the atypical conditions experienced in the summer of '95. This indicates that the users are taking their 'adaptive opportunity' to self regulate their individual thermal environment. In conclusion APU have a successful building that by its passive design characteristics delivers energy savings and achieves a suitable environment.

Operationally we must develop our BEMS to now suit the building and not just the original design principals. Our experience so far has identified those areas that work well and those that do not work so well. By careful monitoring we will be able to informatively design the controls to meet the needs more specifically. We must also continue our monitoring and present the results to the users, for in them we need to instigate a change: from the cultural understanding and speedy response that higher energy use buildings create, to that of the more naturally occurring changes that the building's design principles and construction will produce.

APPENDIX 1

List of Abbreviations:

APU	Anglia Polyt
BEMS	Building Ene
CFC	Chloro - Fluc
HCFC	Hydro - Chlo
HFC	Hydro - Fluor
VDU	Visual Displa

APPENDIX 1

List of Abbreviations:

APU	Anglia Polytechnic University
BEMS	Building Energy Management System
CFC	Chloro - Fluoro - Carbon
HCFC	Hydro - Chloro - Fluoro - Carbon
HFC	Hydro - Fluoro - Carbon
VDU	Visual Display Unit

APPENDIX 2

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ABSTRACT With t
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