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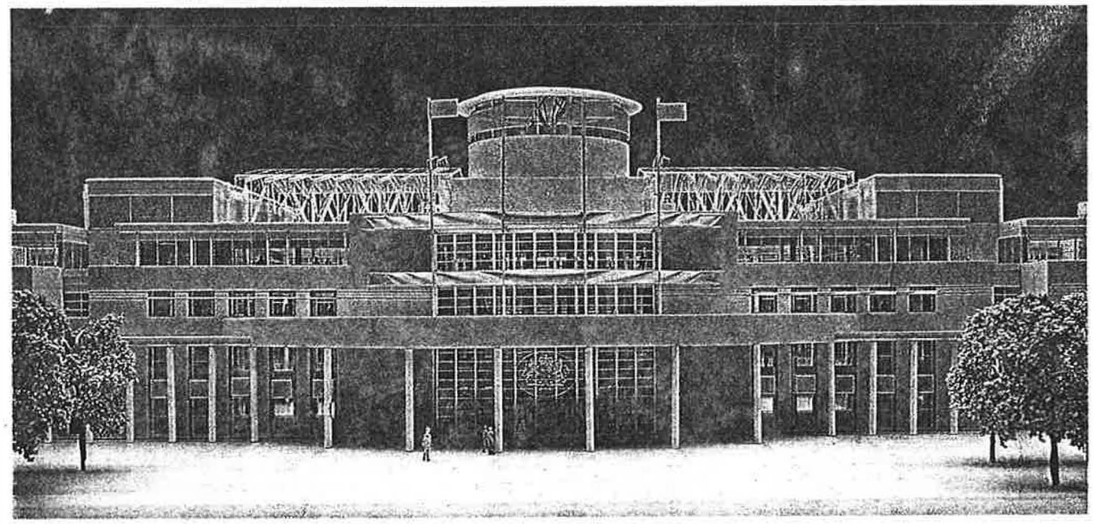
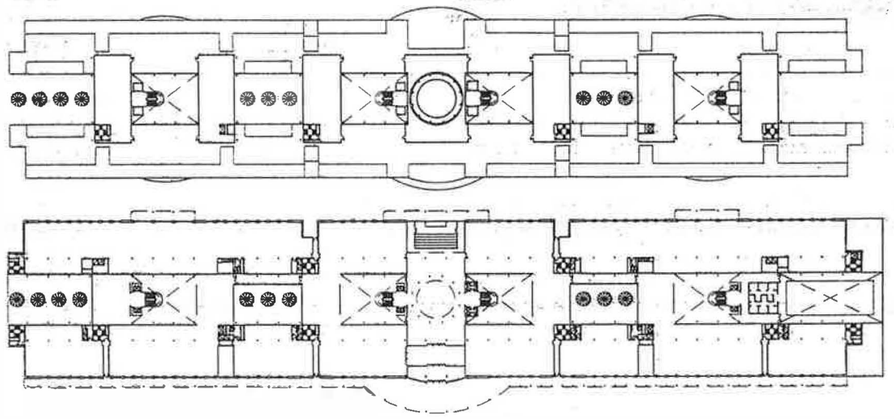


LOW-ENERGY DESIGN AT RMJM

The Energy Design Advisory Service, set up by the RIAS, is in its sixth successful year. Michael Duncan of RMJM Scotland explains how EDAS has been used on projects designed by the practice for widely differing sites primarily in Edinburgh

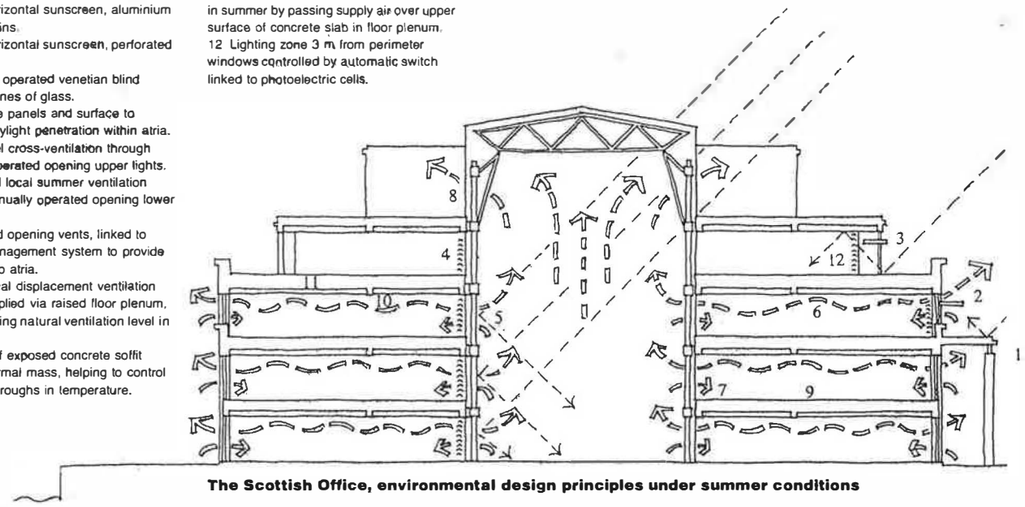
The Energy Design Advisory Service, recently extended to England, has been operating in Scotland since 1987. From 1990, RMJM's Edinburgh office has involved EDAS in a number of projects, principally office buildings in and around Edinburgh, as part of a commitment to low-energy and environment-friendly design. The EDAS involvement has encompassed a range of activities from informal advice, through the testing and appraisal of options to full computer simulations of entire building designs against actual climate data.

Our first approach to EDAS was during the outline stage of our proposals for Victoria Quay in Leith for the Scottish Office. The objective was to produce a building that was energy efficient and that avoided the use of air conditioning wherever possible, concentrating instead on natural lighting, the use of thermal mass for free cooling and mixed-mode ventilation. The site, on redundant dockland, allowed us to orientate the building to provide maximum protection from solar gains. A further benefit was the absence of



Above, model of the Scottish Office, Victoria Quay, Leith. Left, ground floor plan and roof level plan showing the atria along the linear building, creating a series of naturally-lit and ventilated public spaces

1 Colonnade provides solar shade.
2 Fixed horizontal sunscreen, aluminium frame and fins.
3 Fixed horizontal sunscreen, perforated aluminium.
4 Manually operated venetian blind between panes of glass.
5 Reflective panels and surface to increase daylight penetration within atria.
6 High level cross-ventilation through manually operated opening upper lights.
7 Low level local summer ventilation through manually operated opening lower lights.
8 Motorised opening vents, linked to building management system to provide ventilation to atria.
9 Mechanical displacement ventilation system supplied via raised floor plenum, supplementing natural ventilation level in summer.
10 Areas of exposed concrete soffit provide thermal mass, helping to control peaks and troughs in temperature.
11 Thermal mass utilised for free cooling in summer by passing supply air over upper surface of concrete slab in floor plenum.
12 Lighting zone 3 m from perimeter windows controlled by automatic switch linked to photoelectric cells.



The Scottish Office, environmental design principles under summer conditions

traffic noise, and other problems associated with city centre sites, which allowed opening windows and natural ventilation to be provided.

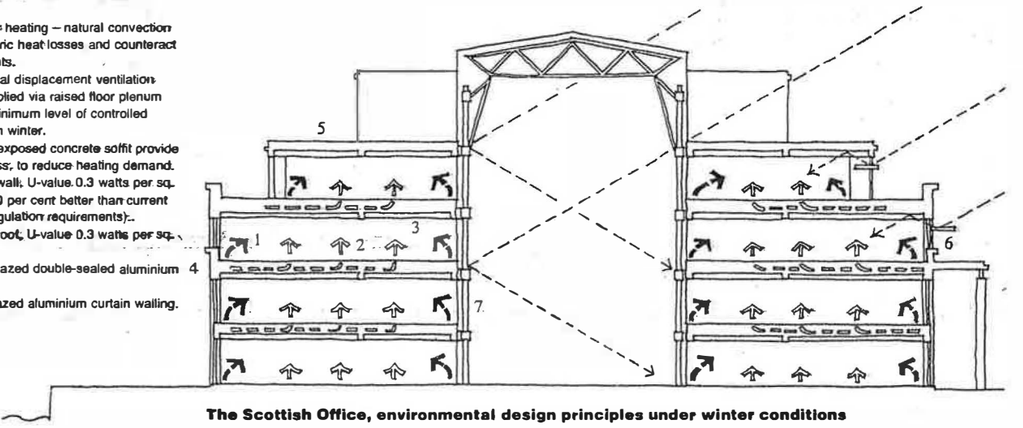
The design evolved from principles first established for the National Farmers Union Mutual and Avon Insurance Group headquarters at Stratford-upon-Avon and envisaged limited options for the location of cellular accommodation, an absence of suspended ceilings, and mechanical ventilation via exposed overhead service booms. The major departure from the NFU model was to be the incorporation of a number of atria in the place of open courtyards. We were concerned at the possible impact of the atria on the performance of natural ventilation and we consulted EDAS to run a number of tests on atrium and courtyard options to determine the optimum configuration.

A computer model of the basic building block unit was set up and tested against three options: a courtyard, a north-light atrium and a fully-glazed atrium. It was expected that, for a building of this type with high casual gains from office equipment, the main environmental problem would be the control of overheating in summer rather than heat loss in winter. The results demonstrated that both atrium options gave a better winter performance by reducing heat losses without detrimental heat gains in summer but that all three performed similarly in overall energy consumption. The final choice of fully-glazed atria was therefore made on architectural rather than environmental considerations.

The computer model was then developed and simulated against real climate data for a full calendar year. Data from Leuchars was used as being the most comprehensive for a site in central Scotland. All design data on casual gains, occupancy levels and working patterns was provided by RMJM. The resultant energy consumption data was converted into estimated annual running costs for submission to the Scottish Office as part of the developer's bid. The EDAS Simulation Report was also submitted, together with a translated and decoded Summary Report as the main report was too complex to be readily understood by a lay reader.

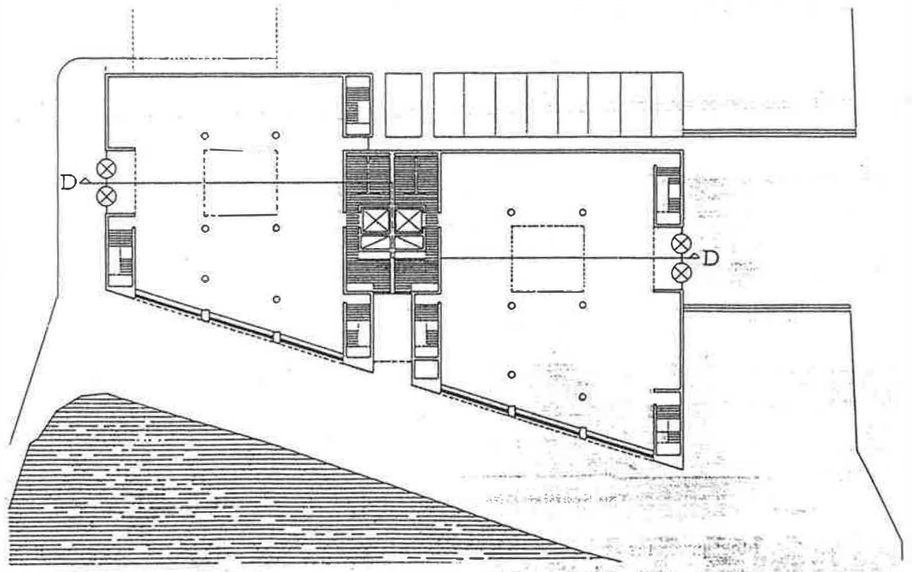
Following this first submission, a number of modifications to the design was requested by the Scottish Office which would have an impact on the environmental performance of the building. These were primarily associated with increased planning flexibility for the location of cellular accommodation, and a requirement for partial suspended ceilings incorporating acoustic quilt.

1 Perimeter heating – natural convection to offset fabric heat losses and counteract downdraughts.
2 Mechanical displacement ventilation system supplied via raised floor plenum providing minimum level of controlled ventilation in winter.
3 Areas of exposed concrete soffit provide thermal mass, to reduce heating demand.
4 External wall; U-value 0.3 watts per sq. m deg.C (30 per cent better than current Building Regulation requirements).
5 Inverted roof, U-value 0.3 watts per sq. m deg.C.
6 Double-glazed double-sealed aluminium windows.
7 Single-glazed aluminium curtain walling.



The Scottish Office, environmental design principles under winter conditions

Ronaldson's Wharf, Edinburgh: ground floor plan (right), side elevation (right middle), and elevation to the wharf (right bottom)



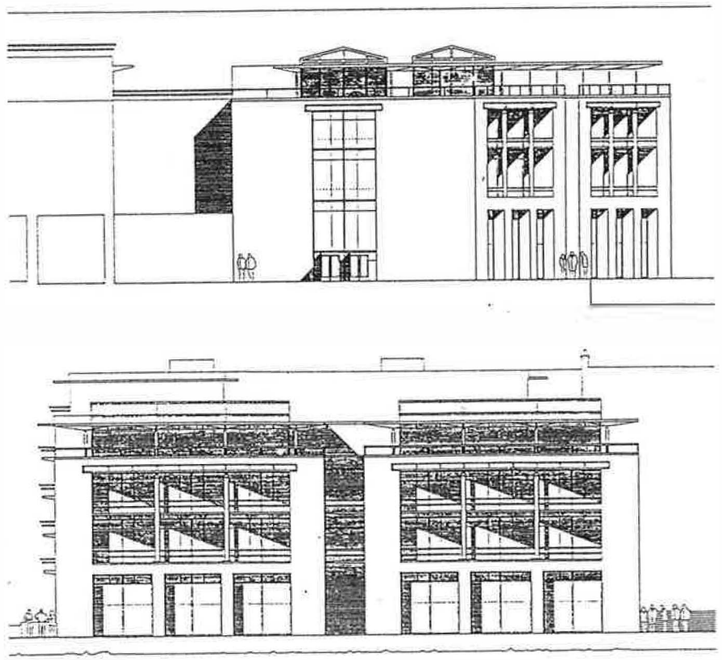
The effect of this was to reduce the area of exposed concrete available for cooling and to interfere with cross ventilation patterns, resulting in higher internal temperatures.

A reappraisal of the servicing strategy in an attempt to maximise the use of thermal mass of the building for cooling led to the adoption of a displacement ventilation system via a raised floor plenum. The design changes were then subject to a further simulation. However, the nature of the simulation was such that it was not possible to identify the effects of individual changes, which items were beneficial and which detrimental. The changes were therefore resimulated against two test 'rooms', each modification being modelled in sequence, to allow the effects to be quantified and an optimum configuration selected.

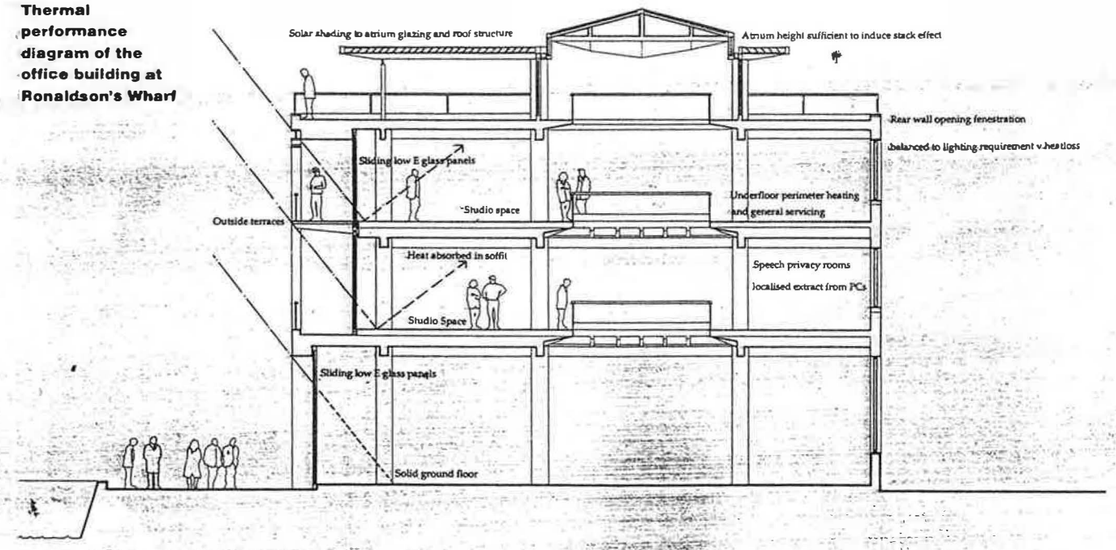
During the evolution of the design for Victoria Quay, we were also involved in a proposal to create a pair of smaller office buildings at Ronaldson's Wharf, also in Leith and partly for our own occupation. As our own accommodation, it was intended that the buildings should reflect our commitment to low-energy design. Unlike Victoria Quay, the Ronaldson's Wharf site was constrained by an existing urban grain and did not allow us to make use of building orientation to help control solar gains. It was therefore necessary to give particular attention to the built form to provide shade and protection if air conditioning was to be avoided. In order to maximise the floor area, a small atrium was incorporated into each block, acting as a central hall, lightwell and ventilation stack.

The early proposals envisaged a lightweight roof formed from composite metal panels. We were concerned at the possible effects that this would have on the performance of the thermal flywheel of the building and called in EDAS to advise on an optimum roof construction and atrium profile. After discussion with EDAS, the roof construction was altered to an inverted concrete roof, maximising the free cooling potential of the structure, and the area of glazing reduced to minimise direct solar gains. A planned full simulation has not yet taken place.

Our proposals for a large office block in the centre of Edinburgh represent an application of low-energy design principles within a more hostile environment. The site is bounded on two sides by main roads, with high levels of traffic noise and pollution precluding significant



Thermal performance diagram of the office building at Ronaldson's Wharf

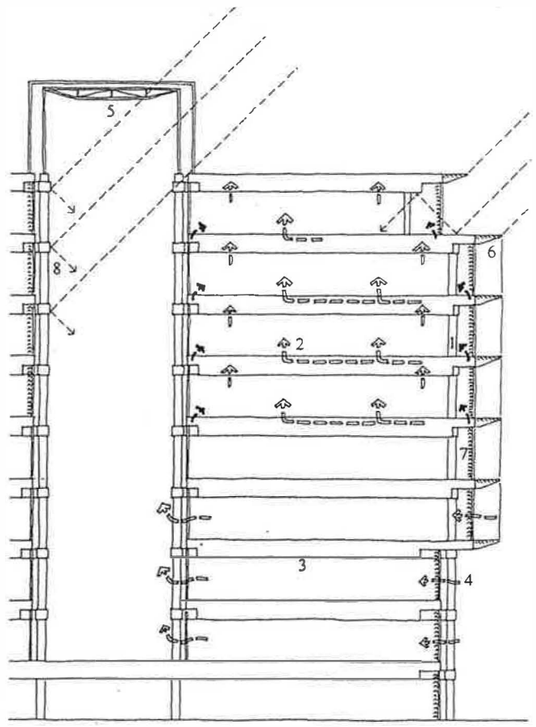


use of natural ventilation or mixed-mode servicing. Further, the level of accommodation required to make the site viable resulted in a building occupying almost the whole site.

We decided to use an underfloor VAV air-conditioning system but to utilise both passive and active systems to minimise energy consumption. In particular, extensive studies into the requirement for solar shading were undertaken, including analysis of sun angles. Atria were provided to allow natural light into the depth of the plan and to act as solar heat collectors providing opportunities for heat recovery during the winter. In addition to sun path and shading tests, EDAS was involved in a number of studies to assess the viability of using thermal mass for free cooling, which was then adopted, and the possibility of using ice storage to assist the cooling load. Following the conclusion of these studies, a full simulation was undertaken to assess the predicted annual energy consumption.

Over the past three years, we have developed a good working relationship with EDAS. As we have both acquired more experience, we have found that the nature of the involvement has changed. From seeking general advice on design issues, we now find that most of our work with EDAS is in testing specific, potentially innovative options in full energy simulations and in testing problems identified during full simulations. In addition, the design advice available from EDAS is now more extensive than it was in 1990.

One of the strengths of EDAS is the extensive package of computer software available for simulations. This does have its drawbacks in the highly complex Simulation Reports produced. It is our experience that the simpler and better thought out the question posed, then the more understandable the answer, but EDAS itself will help to translate Simulation Reports into plainer English. As a tool for the testing and validating of design assumptions, particularly in the fields of natural and mixed-mode ventilation, we have found EDAS to be of considerable benefit. We shall continue to consult the service and look forward to developing these and other projects with EDAS in the future. □



Low-energy design applied to an office block in the centre of Edinburgh

1 Perimeter heating – natural convection to offset fabric heat losses and counteract downdraughts.
2 Underfloor VAV air-conditioning system.
3 Areas of exposed concrete soffit provide thermal mass for free cooling.
4 Windows can be opened if desired, but not required for building performance.
5 Head of atrium acts as solar collector.
6 Brise-soleil provide shade to south elevation.
7 Venetian blinds provide additional solar control.
8 Reflective panels and surfaces increase daylight penetration within atrium.