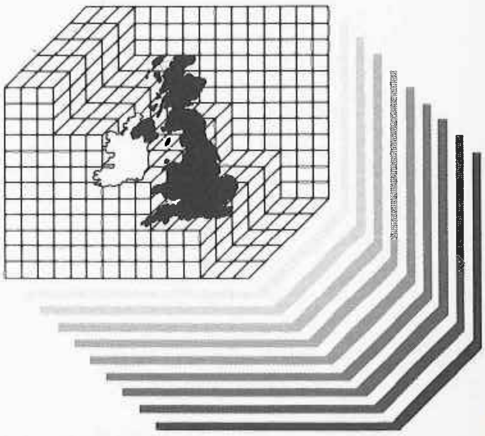
Patterns 2



Patterns 2

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Editor Robbie McElhinney
Technical Editor Michael Dickson

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The Changing Role of the Consultant Engineer in the UK

We produced our first issue of Patterns after eleven years to celebrate a Queen's Award for Export Achievement. That issue showed only overseas work but we saw it as the start of a practice journal which could show more widely how we are trying to advance our work, demonstrated by projects in which we have been involved. We could have produced a twin issue showing all the work we have done in Britain during the same period but that would have just been an historical list. Our real concerns are with the present and the future. Not that the history of our industry is not interesting if only because, by extending it by analogy, it may give us some clues to the future. Although the social and economic environment in this country has changed over the last twelve years, human needs and human behaviour tend not to change much with time.

The industry was very depressed when we first set up. Over the preceding years government and local authorities had developed big design offices and construction organisations of their own, and an economic squeeze meant that little work was given to outside consultants or contractors. Half the skilled workforce in the area seemed to be flying to places like Jeddah, and one could get a skilled carpenter in one's house for £1 an hour. Many in the industry had to work abroad. We were very grateful for our overseas contracts.

This experience led to major changes in our industry. Firstly many in the industry were exposed to an industrial market. Engineers like ourselves had to design for many different physical environments, using materials from many parts of the world and working with contractors from other countries. They had to be both rigorous and adaptable and, not surprising, that competitive scene made many engineers very critical of the standards which were previously achieved in Britain. Secondly it slimmed down the contracting industry which not only became much better managed but, partly to distribute the capital required, took to sub-contracting much more of the work. Thirdly it radically reduced recruitment, education and training for the industry.

In the last few years work for this industry has slowly come back (Fig 1.1). With the current government, the Client for most building has shifted from politicians and their officials to corporations and developers, yet political power is now wielded through planning approvals (Fig 1.2). Public disillusionment with much that was built in the recent past has led to a more legalistic view of designers' responsibilities. While this has not resulted in many changes, and the traditional organisation of functions in the design of large buildings still remains, it has led to the

Fig 1.3 Royal College of Art, London – inner city refurbishment within an extremely short construction period

Fig 1.2 Government promoted renewal – The Liverpool Garden Festival

Fig 1.1 The Colonnades, Bath St, Bath – an example of recent urban refurbishment

reintroduction of the design of many technical elements by sub-contractors or suppliers. Speed of construction is now a critical factor (Fig 1.3).

What is obvious from these developments is that the technology in building is becoming more important, not less. Not only is the organisation of building work becoming more critical (and engineering is largely about the organisation of work) but the technical performance of designs is also more important (and the prediction of performance is the engineer's other main skill). Function plus economy is always every engineer's objective. The assumption that there is a body of well established methods of building proven with time, known by craftsmen and robust enough to cope with errors, is obviously now suspect. You only have to look at a modern cavity wall to realise this. Not only is a higher level of performance required of it, entailing the use of new materials, but there is a shortage of craftsmen trained in constructing that wall.

The organisation and supervision of work on site is often the training ground for the workforce. One might assume that these tasks will be taken on by sub contractors and suppliers but I doubt it. Modern structures in reinforced concrete or structural steelwork were originally supplied by design-and-construct firms but such firms now only hold a small proportion of the market and most structures are consultant designed. It is estimated that there is now only half the weight of steel (reinforced or structural) in a current building structure compared with immediately post Second World War. The design of building services systems too has increasingly moved from design-and-install firms to consultants. It is hard to believe that, just as Clients want independent architects, they will not also want independent engineers.

We have always believed that there is a major difference between architecture and engineering, though both are needed. We set up to work as structural engineers with good architects. Since the true difference between structure and services is secondary and they interact strongly in the design of buildings, we developed that skill. Since we believe that you cannot design without understanding the costs we extended our compass. To minimise cost one must be able to analyse the process; to build well one must develop in project management and site supervision; to consider a building in context one must understand the physics of its environment (Fig 1.4), its traffic problems and the like; to handle materials one must understand the science of materials (Fig 1.5). All these interests we are studying and supplying in this practice. All are engineering and our ambition is to do good engineering with good architects, to produce good buildings. We have grown to our present organisation partly out of interest and partly from opportunity. Some of the projects discussed in this issue illustrate this. Others such as the Vauxhall Cross competition illustrate it even more (Fig 1.6). A sharing of this experience is what this journal is about, it is a mirror to our learning experience.

Ted Happold

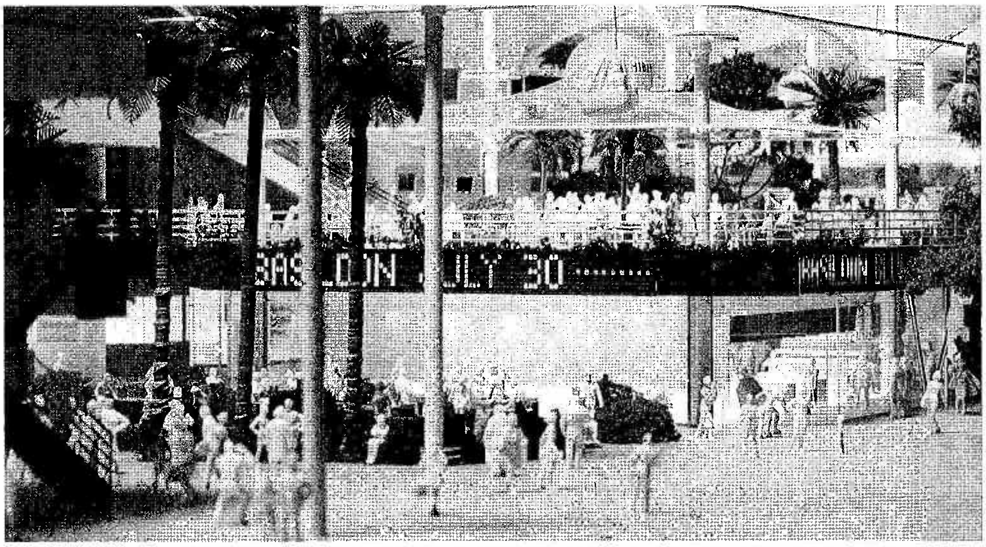


Fig 1.4 Basildon Town Square – specialist lightweight structures and building physics knowledge (Architect: Michael Hopkins)

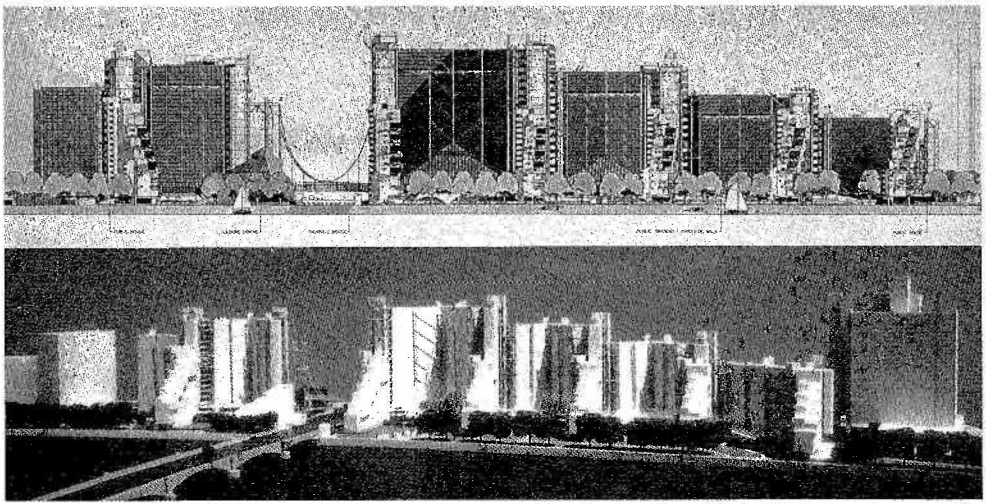


Fig 1.6 Vauxhall Cross competition winner – a combination of engineering skills (Architects & Engineers: Sebire Allsop & Happold)

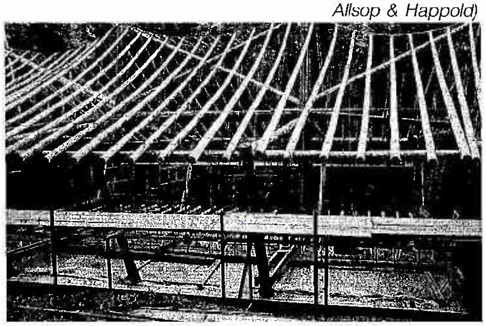


Fig 1.5 The School of Woodland Industry, Hooke Park, Dorset – use of jointed green roundwood timbers (Architect: ABK with Frei Otto)

An Extension to Worcester College, Oxford

Project Data

Client	Worcester College, Oxford
Architect	MacCormac Jamieson and Pritchard
Civil/Structural Engineers	Buro Happold
Services Engineers	Buro Happold
Quantity Surveyors	Hamilton Turner
General Contractor	N E Chivers
Civil Contractor	Hope & Clay
Cost	£1m
Completion Date	1982

In 1979 we joined architects MacCormac Jamieson and Pritchard in a competition to design a new residential building, later to be called the Sainsbury Building, at Worcester College in Oxford. The building does not show its structure or its mechanical and electrical services in an extrovert way, but many are surprised at the depth and complexity of the engineering design in a building which is so domestic in its appearance (Fig 2.1).

The outward appearance of the building stems from its relationship to the Worcester College lake, the Provost's garden and the playing fields (Fig 2.2). The interior of the building stems from a study of the uses of the various rooms and corridors, the desire for sound insulation between the student rooms, the intermittent and unpredictable occupation of the student rooms, and the more consistent occupation of the student kitchens, dining rooms, bathrooms, internal corridors and the public corridors.

Internal Environment

As can be seen in Fig 2.3 the kitchens, dining rooms, interior corridors and bathrooms form the spine of the building. They are maintained constantly at normal room temperatures. The "semi public" corridors are positioned along one side of the spine and are maintained at a lower temperature but act as a buffer between the internal spaces and the outside. These "constant" temperature spaces are built with mass walls of concrete and blockwork.

The student bedrooms are located on the other side of the space. Although these are constructed in dense concrete blockwork to provide sound insulation between the rooms, and are of brick and lightweight cavity wall construction on the external walls, they are also lined in insulation backed plasterboard. This allows a quick temperature response when the heating is boosted. The student rooms (Fig 2.4) are maintained at a temperature of 13°C and can be boosted by the student, when required, to normal room temperature. The time during which the student calls for this additional heating is monitored and the student pays for this heat.

Generally, the shell of the building was designed to have an insulation value of 0.3 W/m²°C. The roofs are insulated with 150mm of rockwool. The ground floor levels have perimeter under floor insulation. Floors with exposed soffits are insulated underneath and the windows and doors are double glazed and well fitting.

In the early stages of the design, studies were made of alternative heating systems including

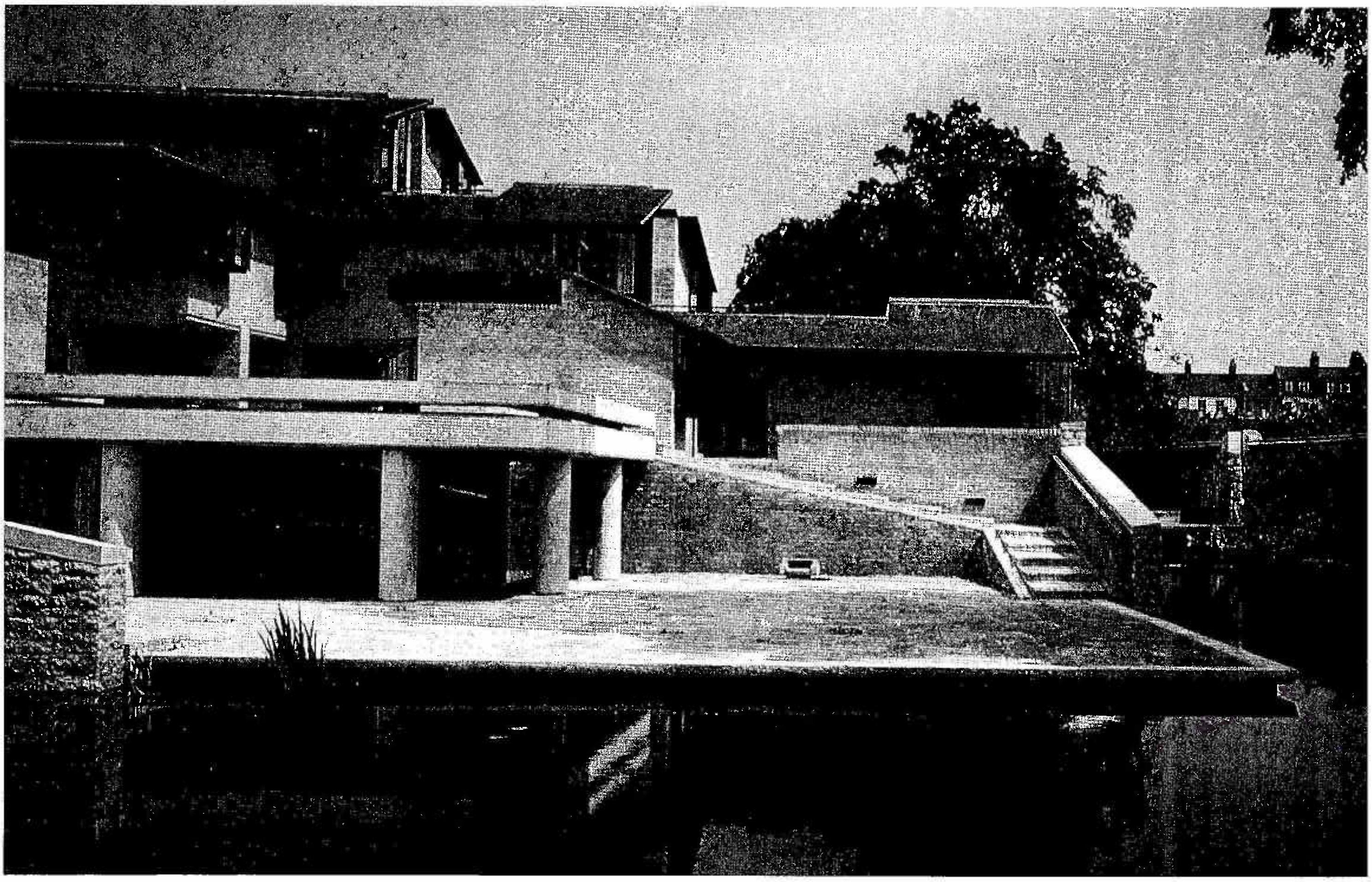


Fig 2.1 *Terracing and 'stepped' levels of Sainsbury Building*

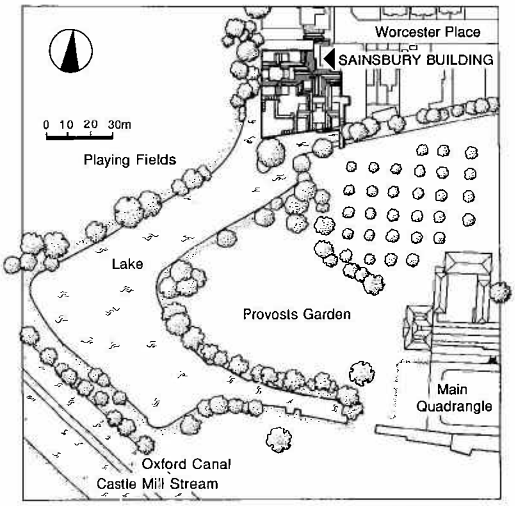


Fig 2.2 Location of Sainsbury Building within Worcester College

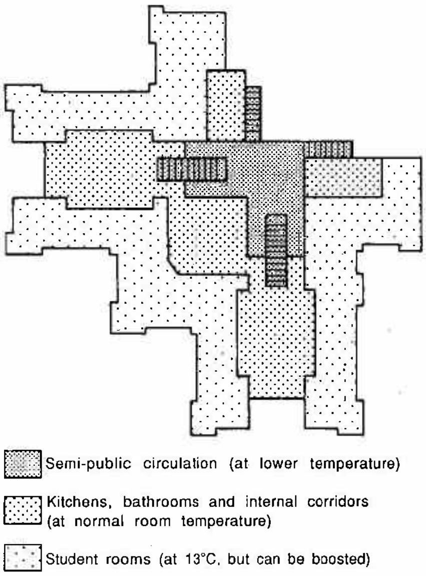


Fig 2.3 Heating plan for varying internal environment

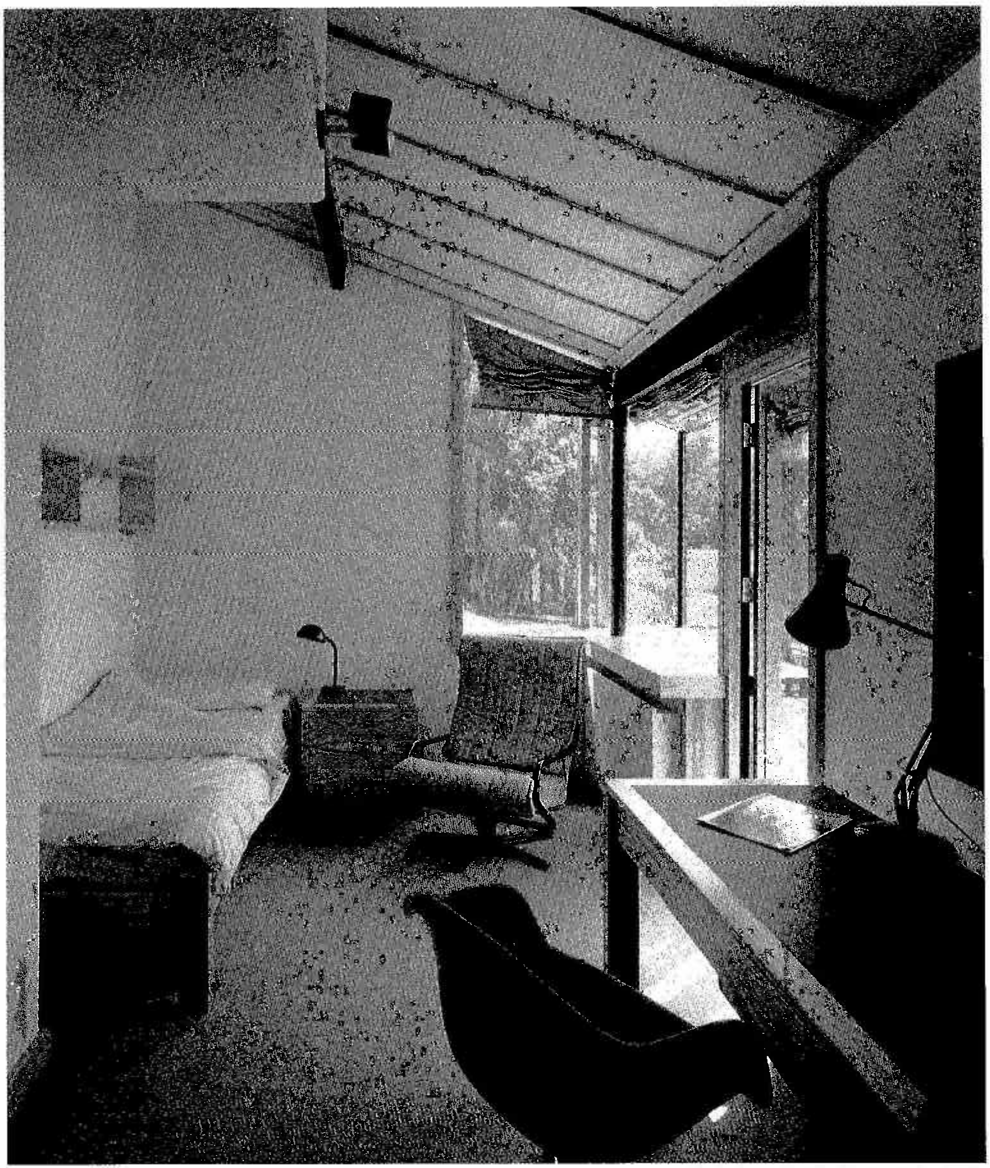


Fig 2.4 Detail of student bedroom

various forms of gas, off-peak electric and heat pumps. Capital costs, running costs and maintenance costs were included in the study and on this basis twin gas boilers were chosen for the heating system, with a separate gas boiler for the domestic hot water (Fig 2.5).

The rooms are heated with convector radiators controlled by the twin thermostat control system in the student rooms and thermostatic radiator valves in the remainder of the building. High output convector radiators were chosen in preference to fan coil units for their quietness and lack of maintenance needs.

The effort made with respect to the design of the heating system and the construction of the building are justified in the resulting low energy consumption.

Structural Design

The overall pattern of the building is one in which each floor steps back from the one below, providing terraced gardens at each level and relating to the surrounding landscape (Fig 2.6). The result on the structure is that very few of the walls at one level relate to those at the level below.

For environmental reasons, as explained above, mass walls were required in much of the building. It was decided to use these walls as load bearing. However, these load bearing walls sit sometimes on suspended slabs and in other cases on cross load bearing walls at the floor below causing stress concentration within the walls. Extensive analysis of the in situ reinforced concrete slabs was made

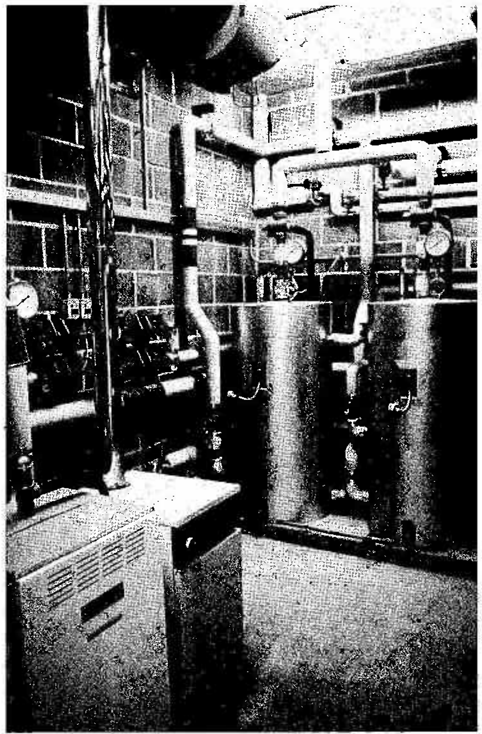


Fig 2.5 *Plant room for heating system*

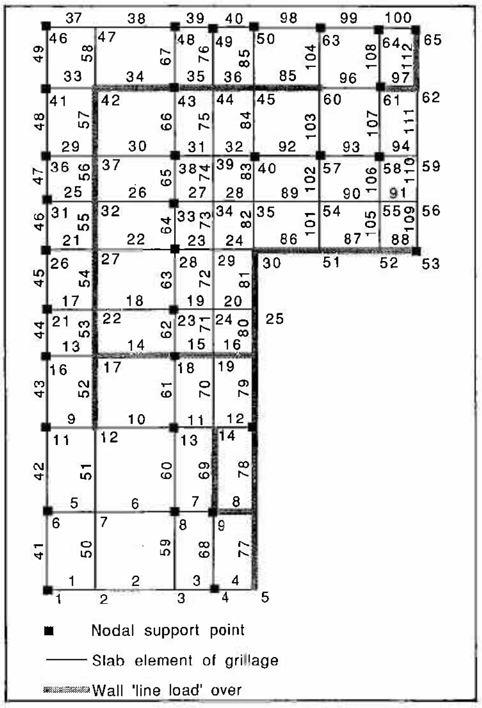


Fig 2.7 *Elastic analysis of 'grillage' analytical model*

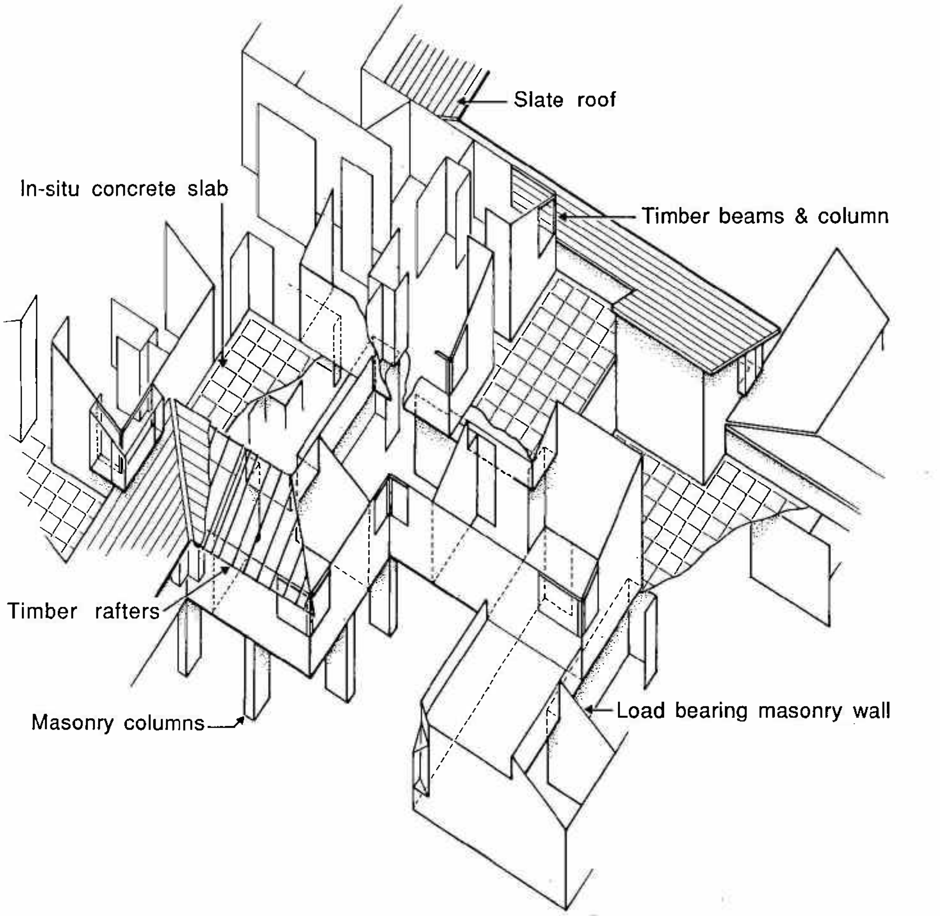


Fig 2.6 *Axonometric showing building levels and main structural features*

using the Minitec grillage program (Fig 2.7), and care was taken to keep deflections and, in particular, curvatures of these slabs within acceptable limits. A grade (iv) cement : lime : sand mortar was used to allow the maximum possible tolerance to movement in the blockwork. Horizontal reinforcement was used at points of stress concentration.

Landscaping Details

The Worcester College lake is not large, but is an important part of the life of the College (Fig 2.8). It was extended up to the new building and an island was formed around a mature silver lime tree. Weirs were created down one side of the building with the lake overflow at the other side. Water is pumped to the weirs to cause water movement while maintaining a "black" water appearance. The weirs were formed using precast concrete to precise tolerances to allow a film of 6mm of water to pass over them and to cling to the face of the weir before arriving at the next level.

The lake is an artificial one with the water level some 1.5m above the natural water table. Originally, the lake had been formed with puddled clay. It was extended using a layer of bentonite and sand mixed and covered with a layer of 20mm aggregate. As bentonite expands dramatically when made wet, within the mixture of sand and with the gravel over it, this expansion forms a water seal.

The common room looks out over the lake and has a floor level below the artifical water level and a roof which is an external terrace (Fig 2.9). The lower part of this part of the building is constructed in watertight concrete and the upper in in-situ fairfaced bush hammered concrete.

Our first job was to divert the 4'6" brick sewer passing across the site for the building and serving a large section of Oxford. This work was carried out under an ICE form of contract by contractors Hope & Clay.

Feedback From Users

It is rare that the users of a building are asked their opinions about it after having been in occupation for some time. A survey of resident students' views was made and the results of the survey are given in Table 2.1. It is pleasing to receive such favourable response to our efforts.

The building was completed in 1982, at a cost of approximately £1m, and achieved a Civic Trust award in 1984.

Rod Macdonald

Fig 2.9 Common room with view to terraced garden

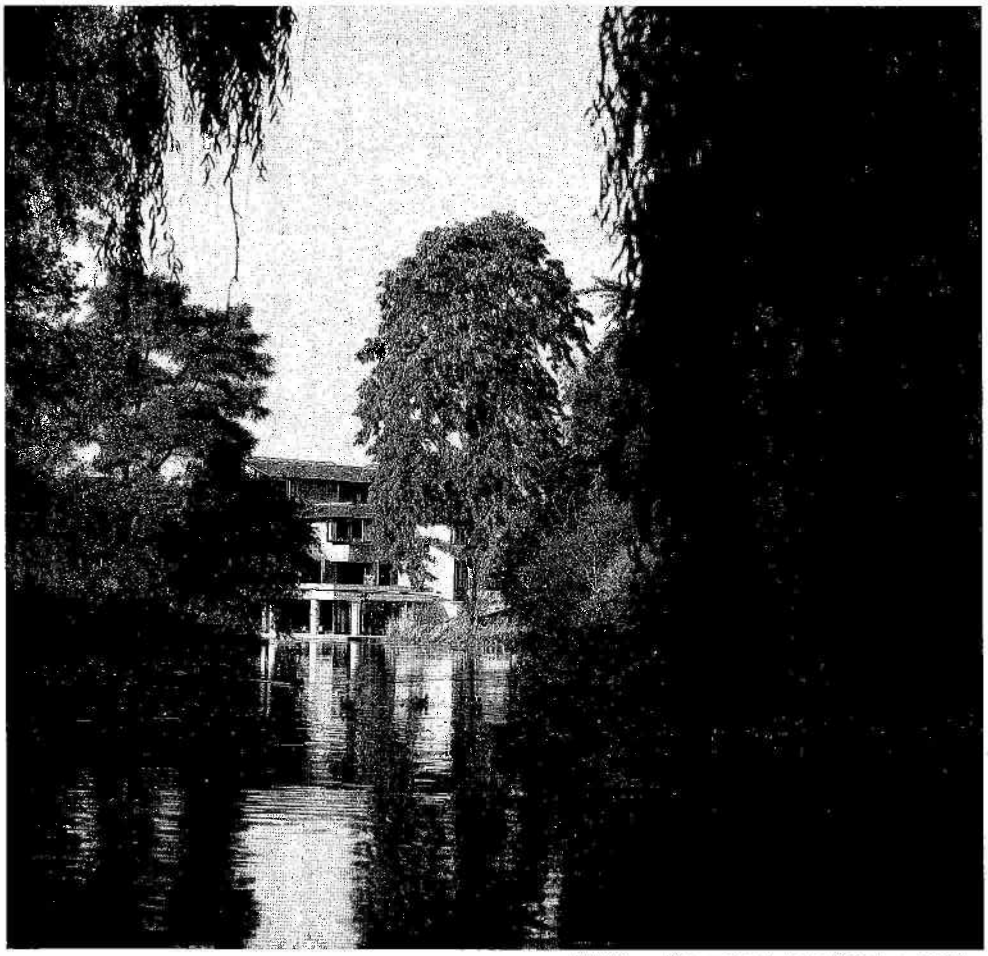


Fig 2.8 View across lake to Sainsbury Building

Table 2.1 **Students' reaction to Sainsbury Building Worcester College***

	Excellent	Good	Satisfactory	Unsatisfactory	Not used/no comment
Rooms					
Size	1	4	6		
Natural lighting	6	2	3		
Artificial lighting	3	6	1	1	
Heating	7	4			
Ventilating	3	4	3	1	
Furniture and equipment	8	2	1		
Storage space	2	2	4	3	
Views	5	2	4		
Colours and materials	5	4	2		
Acoustic insulation	2	5	3	1	
Communal kitchens					
Size	6	3	2		
Equipment (cooking rings)	2	5	4		
Storage	7	4			
Materials	6	3	2		
Colours	5	5	1		
Bathrooms and toilets	9	2			
Corridors, staircases, circulation	5	5	1		
Terraces and/or balconies	10	1			
Building from outside					
Form and shape	11				
Materials	11				
Colours	8	2	1		
Landscape					
Terraces	9	2			
External (including lake)	10	1			
Common room and the deck					
Size	2	5	3		1
Views	9	1			1
Bicycle room					
Size	2	4	4		1
Position	6	3	1		1
Launderette					
Size	4	6	1		
Position	6	4	1		

*Based on questionnaires completed by 11 students

Fire Engineering

As buildings become more complex and the demands of users more diverse, fire safety needs and safety measures are not as easily defined. In response to the need to define and solve these problems, fire safety engineering has developed and become an important part of the total building design process. A more flexible approach to design is possible than that normally prescribed in the Building Regulations. Nevertheless not every building requires to be fire engineered since the prescribed solution is sufficient in many cases and gives a perfectly adequate and economic solution.

At its most powerful fire engineering can contribute significantly to the development of building form and construction strategy. More usually a problem has been defined in general terms and a solution requiring the specification of materials, equipment and construction detail is appropriate.

Fire engineering is a broad discipline involving a wide range of activities and specialist interests which are supported by vast amounts of research and codified information. The uncertainty of real fires and the fact that data is not organised in an interactive way results in differing interpretations and consequently significant variations in the level of safety results. The development of a methodology and decision making process is therefore fundamental if fire safety is to be maximised, whilst responding sensitively to the architectural and engineering requirements at reasonable costs.

Fire Safety Needs

Before it is possible to establish fire protection measures, the fire safety need must be established by reviewing the potential risks. It is this review process that leads to wide variations in interpretation and levels of safety which present the designers and Fire Authorities with most difficulty. The primary risks, assessed in relation to planning, spatial geometry and use, fall into the following categories:–

Life Safety
Exposure to toxic gases.
Disorientation and reduced visibility due to smoke.
Panic.
Inhalation of heated air.
Chance of ignition.
Rate of fire growth.

Conflagration
Rate of growth of fire.
Vertical spread of fire.
Lateral spread of fire.
Spread of hot gases.

Protection of Property
Chance of ignition.
Rate of growth of fire.
Damage to property by heat and water.
Damage to structure by heat.
Consequential losses.

Society places most importance on life safety aspects followed by risk of conflagration. Protection of property although not so emotive, is still important and is never totally independent of life safety or risk of conflagration.

Fire Protection Measures

The specification of fire protection measures are a direct response to the requirements of the fire safety need or specified fire grade of the proposed building. It is at this stage that the decision making process and development of the fire engineering, backed by detailed analysis, is developed.

Fire Size and Growth
If the growth of a fire is limited by sprinklers or low ventilation it is possible to define a single fire size. References are as indicated ( ).

Spinklered fire in a shop = 5MW	(1)
Spinklered fire in an office = 0.7MW	(2)
Non-sprinklered fire in an office = 4.1MW	(2)
Hotel Room	(3)
Statistical data	(4) (5)

If a fire can continue to grow such that fire brigade action is the only control, a full and developing range of fire sizes must be accounted for.

The standard fire test exposure is defined by

$$T - T_o = 345 \log_{10} (8t + 1)$$

where

t is the time (min)
T is the furnace temperature at time t
T_o is the initial furnace temperature

Real fires tend to grow exponentially

$$A_f = A_o e^{(\alpha t)}$$

Where

A_f is the floor area damaged at time t.
A_o is the floor area originally ignited.
α is the fire growth parameter.

Typically a value of 4 min for a doubling time giving

= 0.0029 s 1 (11) (15)

Smoke Control
Knowing the fire size it is possible to estimate the vertical and lateral spread of smoke and to specify appropriate safety measures to limit risk to life, and further growth of fire.

References:–

Smoke plume analysis	(6) (7) (8)
Shopping Malls	(9) (11) (12)
Atriums	(13) (14)

The fire protection measures available are considerable and varied but can be divided into three main categories in increasing order of reliability:–

Management actions which rely on human factors, organisation and training.

Active Fire Protection measures which rely on detection and response which activate mechanical, electrical or air systems to drive smoke vent fire shutters etc.

Passive Fire Protection measures which are permanently incorporated into the building construction including such elements as fire resistant walls and floors, compartmentation, corridors and stairs for escape.

Fire Grading and Interaction of Fire Protection Measures

It would be quite feasible to represent the fire safety need of a building by a "Fire Grade" which could be defined in very simple terms depending on whether people or property were at risk. In shopping malls or public places the fire grade would be directly related to the number of people at risk whereas in an automated warehouse it would be related to the fire load or potential losses.

One of the most important aspects is life safety which is closely related to the acceptable means of escape time. If it is possible to define an acceptable interaction between the number of people, the means of escape time and the fire protection measures, a flexible and logical approach to design will be allowed. An example of a strategy for defining the decision making process is encompassed in Table 3.1. The fire grade is defined as a function of the number of people at risk with a minimum set of fire protection measures allowing a 2.5 minute escape time. A further increase in escape time is allowed giving a maximum total escape time of 4 minutes by the addition of further appropriate safety measures. Although this example is in the early stages of development, it is clear that this tabular approach can be applied to many aspects of fire engineering where interpretive decisions need to be made with some degree of consistency.

Enclosures

Atria, shopping malls, arcades, covered streets, sports grounds or even small towns, as enclosures, are important examples where fire engineering allows a degree of flexibility giving the design team greater freedom to develop their brief imaginatively.

Project Data

Bath Street, Bath

Client	Grosvenor Square Properties
Architect	Rolfe Judd Group Practice
Structural & Service Engineers	Buro Happold
Quantity Surveyor	V J Mendoza & Partners
Contractor	Kier Western
Date	1988
Cost	£3m

Table 3.1 **Fire protection measures as determined from assessed fire grades**

Assessed fire grade	No. of people at risk	Minimum provisions allowing 2½ min basic escape time					Further provisions allowing variation to basic means of escape time (+1½ min maximum)			
		Fire resistance and passive fire protection measures	Active fire protection systems	Early warning	Management capability	Smoke control scheme	Additional fire protection systems	Smoke control system	Management capability & early warning	Significant storey exits onto mall
							½ min	½ min	½ min	–½ min
F1	< 1000	To Building Regulations	A1 No Sprinklers	W1	M1	Not required unless 2 or more storeys. Direct travel distance in shop & mall < 30m	A1 plus sprinkers	Applicable for single storey malls only	M2 W2	Not applicable
F2	< 2000	To Building Regulations plus special measures for shopping malls	A2 plus Sprinklers	W2	M2	Smoke control analysis required and clearance to smoke layer = 2.5m ground floor = 3.0m first floor	A3	Clearances to smoke layer increased to = 3.0m ground floor = 3.5m first floor	M3 W3	Not applicable
F3	> 2000	To Building Regulations plus special measures for shopping malls	A3 plus Sprinklers	W3	M3	Smoke control analysis required and clearance to smoke layer = 2.5m ground floor = 3.0m first floor	A4	Clearances to smoke layer increased to = 3.0m ground floor = 3.5m first floor	Not applicable	If escape time from perimeter buildings into mall is significant reduce escape time

(A1→A2→A3) represents increasing quality of Active Fire Protection Systems
(W1→W2→W3) represents increasing effectiveness of Early Warning Systems
(M1→M2→M3) represents increasing Management Capability

It is interesting to compare the Victorian arcades, still scattered in our northern towns and cities with their modern counterpart, the shopping mall, in order to appreciate the scale and related technological requirements of modern development. The design of the arcade was guided by the desire to provide enclosure and a pleasant environment consistent with the small scale. Similar sentiments apply equally to modern shopping centres, which provide an interesting, though now quite common, fire safety problem due primarily to their much larger scale.

There are no text book solutions available to ensure the safety of these enclosures and so the development of fire engineering strategies and techniques has become more important.

This is illustrated later in the fire protection measures taken on three different development sites.

Bath Street – A Shopping Centre Enclosure

The Bath Street shopping development, situated near the Pump Rooms in central Bath, although not a very large project, posed a number of interesting design problems (Fig 3.1).

The main risks, in common with similar shopping developments, are from smoke and spread of fire, though in this case offices, shops and flats all in fairly close proximity to this restricted site. The relatively small scale gave the option of dividing the total volume into two 7000mm compartments as an alternative to the traditional solution of sprinklering to limit spread of fire.

This solution was eventually discounted due to the practical difficulties of installing fire shutters and the costs of providing a smoke control scheme for a non-sprinkler controlled fire.

The three levels of shopping, including a basement and two upper levels, are too high and complex for a simple naturally ventilated smoke control system. This aspect, in conjunction with the restrictions of the site boundary and restraints imposed by the existing buildings, has resulted in a hybrid smoke control solution. Chimneys up to 2m² vent smoke naturally where these can be economically incorporated in the construction. However in basement front shop units, where this was not possible due to the costs of building chimneys in prime letting space, an underground mechanical system was adopted. This made use of existing arched basements under the pavement as smoke plenums venting smoke through existing pavement grills.

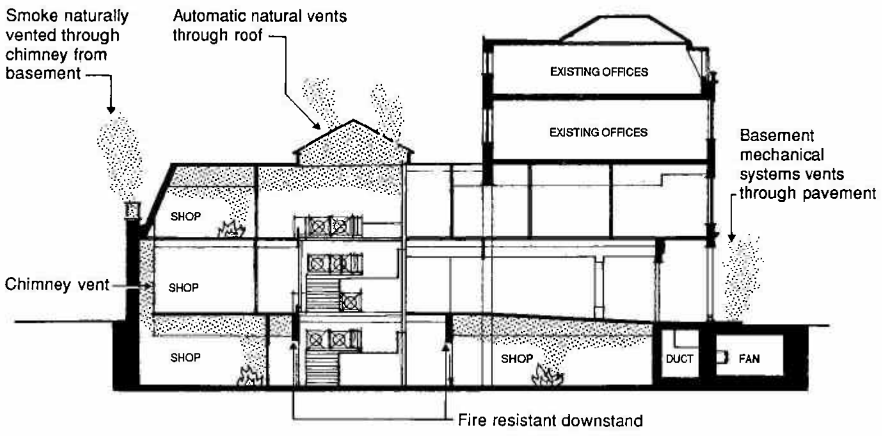


Fig 3.1 Bath St section – smoke control strategy

Project Data

Buckingham Gate, London

Client	Chesterfield Properties
Contractor	Lovell Construction
Architect	Rolfe Judd Group Practice
Structural Engineers	A E Beers
Structural, Fire & Environmental Engineers (for atrium)	Buro Happold
Quantity Surveyor	E C Harris
Date	1989
Cost	£30m (Atrium £1m)

At ground floor level, natural ventilation into the mall or direct to the outside was used for units with simple smoke flow profiles. In some cases the rising smoke plumes were too wide due to the complex mall geometry. This resulted in cool smoke with poor venting qualities, and smoke chimneys were introduced as an alternative solution. Natural ventilation, through automatic opening vents in the mall roof, was used for smoke control at 1st floor level. The mall roof was situated in a hollow in the building scape thus ensuring no significant adverse wind affects.

Part of the structural and architectural concept of the Bath Street development was the glass lift support structure which was required to support the roof as well as the ground and 1st floor slab edges. Two of the four circular columns which supported the slab edge would normally be fire protected while the other two which only supported the roof would not require this. A simple constructional solution avoiding the use of intumescent paint was adopted. The lift columns were only used to support the floors, to minimise normal day-to-day deflections. This allowed the concrete floor structure to be designed to support the ultimate loads during a fire in the unlikely event of the columns failing.

Buckingham Gate – An Atrium

Buckingham Gate is a major re-development scheme adjacent to Buckingham Palace (Fig 3.2). It consists of a covered triangular courtyard surrounded on two sides by important historic buildings. Two atrium elevations are new and the other is a listed masonry facade.

In an atrium the primary concern is to limit the rapid spread of fire and smoke up through to the atrium void (Fig 3.3). There are several principal ways of limiting this spread.

One method is by the containment of the smoke and fire to the floor of origin, keeping the atrium free of fire and smoke. This is achieved by the provision of fire-resistant glazing in the elevations or by smoke containment using mechanical and ductwork systems.

A second method is by the provision of sprinklers to limit growth of fire and hence quantities of heat and smoke. Smoke is then extracted from the atrium by mechanical means.

A combination of less expensive smoke-control glass with a smoke control scheme offers a good hybrid solution as a third method. However, with the possibility of fire spreading up an atrium elevation, risks are less clearly defined. More tests similar to those used on the continent for smoke-control glass would provide a useful database for this scenario.

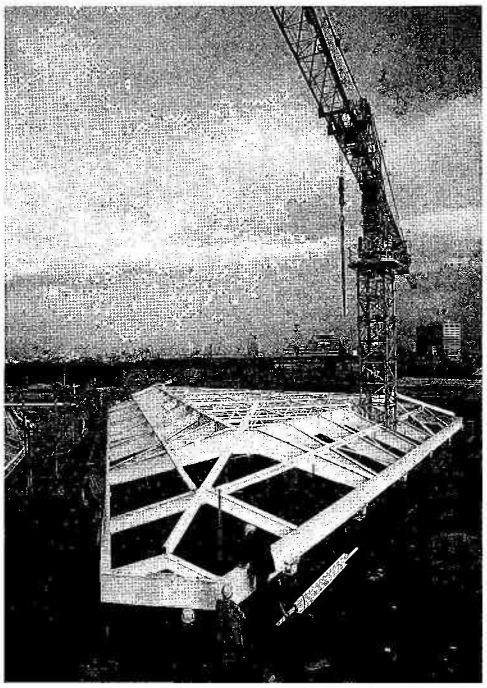


Fig 3.3 Buckingham Gate atrium roof

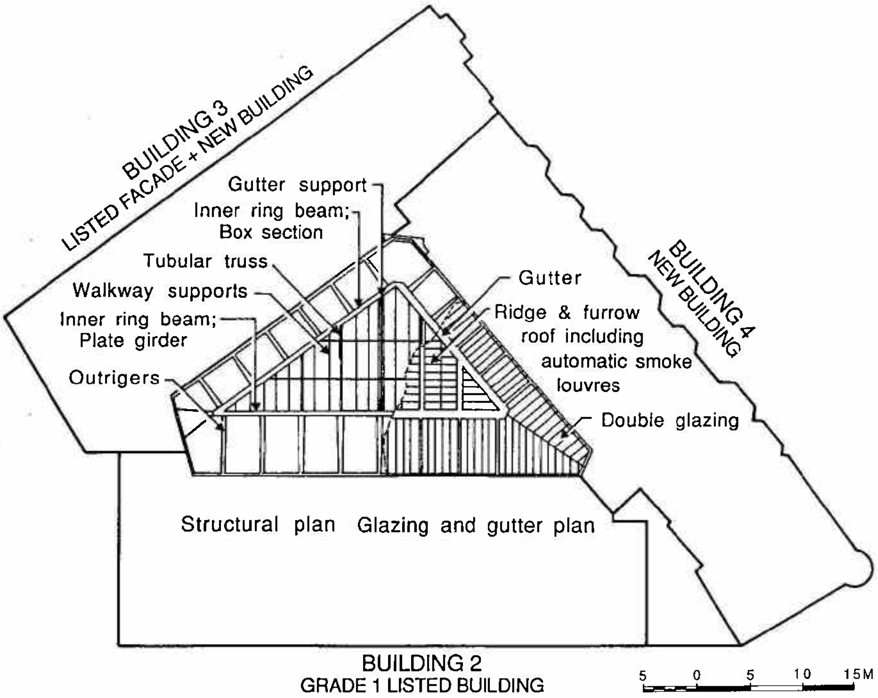


Fig 3.2 Atrium roof construction – Buckingham Gate

The variety of uses considered for the surrounding buildings and for the atrium itself has provided a very interesting means of studying the gradation of fire safety provisions for different cases. These included the possibility of hotel use with atrium as lounge or restaurant, and that of office use with atrium as either transient or as occupied space.

Hotel with Atrium as Restaurant and Lounge
A study of atria, including examples in USA and Scandinavia, revealed a wide variety of fire safety provisions. In a large proportion of cases both in the UK and abroad no fire-resistant glazing was provided to protect the bedrooms overlooking the atrium from hot smoke. However, in London fire resistant glazing would probably have been necessary under GLC requirements.

Office Use
A hybrid solution, as outlined earlier, using toughened glass and a fairly sophisticated smoke control scheme was first considered. This combined the advantages of mechanical extraction of cool smoke with the large capability of a natural

Project Data

Towngate Plaza, Basildon

Client	Tops Estates
Architect	Stanley Bragg Partnership
Structural, Services & Fire Engineers	Buro Happold
Quantity Surveyor	E C Harris
Date	Not yet determined
Cost	£10m

ventilation for the larger non-sprinklered fires (Fig 3.4). In the final analysis this option, with the atrium as a circulation space only, was discarded due to the scale of the problem and the risks involved.

A further solution with the option of using the atrium base as an office was then studied. It was not feasible to incorporate a mechanical system to extract smoke floor by floor due to the restricted existing headroom restraints. The area of windows overlooking the atrium had been reduced which had made the use of half-hour non-insulated fire-resistant glass economically viable. The exception was the existing listed stairway which was isolated using one-hour insulated glass to ensure safe means of escape. The resultant smoke control scheme was nominal and was primarily for secondary smoke clearance purposes. This final solution was selected and is currently under construction (Fig 3.5).

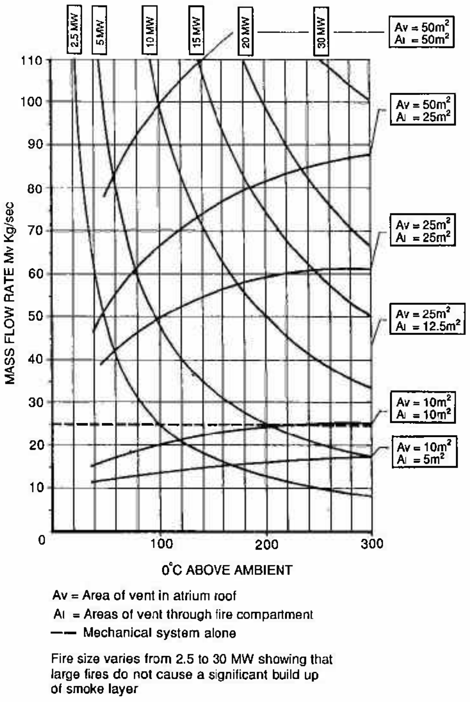
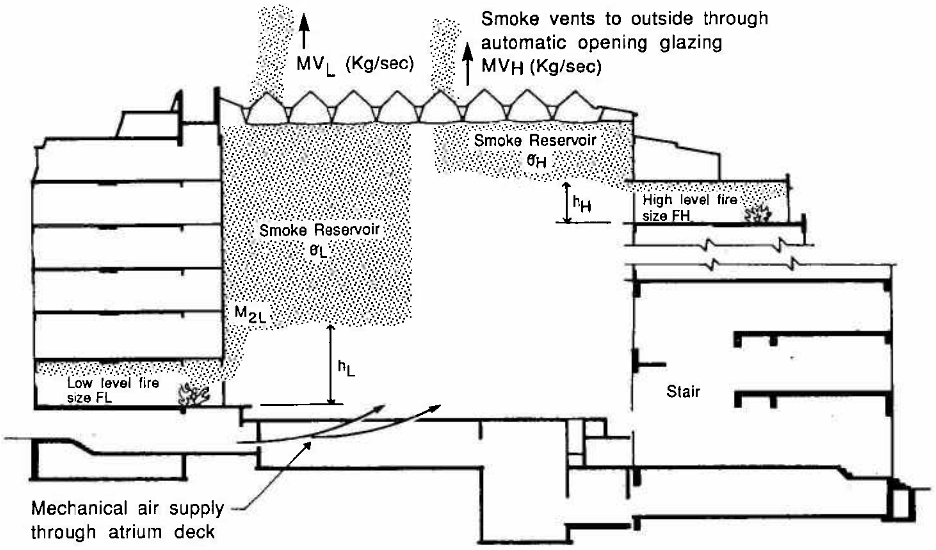


Fig 3.4 Smoke control analysis graph – Buckingham Gate

Fig 3.5 Section through atrium, Buckingham Gate – Fire engineering design



1 If fire size F = F parameters relating to smoke control are

$M_{VL} > M_{VH}$ (Kg/Sec)

$O_L < O_H$ (°C)

$h_L > h_L$ (M)

2 Stair is separated from atrium by fire resistant glazing which has insulating quality.

3 Office windows overlooking atrium to have smoke control glass. Varies from toughened to fire resistant glazing depending on the risks involved and smoke temperatures.

4 Care must be taken with smoke control analysis to ensure that smoke remains sufficiently buoyant to vent. Heat loss from smoke to building fabric may require study.

Basildon Town Square

Basildon Town Square is approximately 200m long by 36m wide. The existing buildings around the square are typically 3 to 4 storeys high and are a mixture of shops, offices and flats.

With the exception of a few larger stores many of the existing shops and offices are unsprinklered. In a new build situation all of the properties surrounding the square would normally be sprinklered to control the development of large fires and volumes of smoke. In this case, it was not practical to add sprinklers throughout and the fire protection measures were therefore designed to account for non-sprinklered fires (Fig 3.6).

The introduction of a barrier to form a series of smoke reservoirs in the roof conflicted with the aesthetics of the roof and so an alternative solution was sought. The roof profile and vent locations were developed to account for a growing fire and to limit spread of fire while accounting for continuing heat losses (Fig 3.7).

The smoke development and spread of smoke was based on the above smoke plume analysis channel flow equations and Newtons law of cooling.

These three examples serve to illustrate the diversity of fire protection measures available in the developing study of fire engineering.

Mick Green

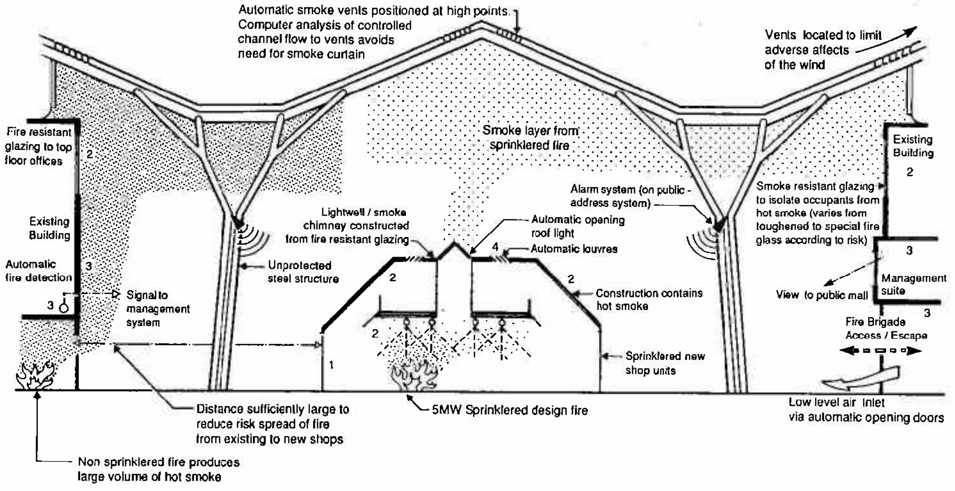


Fig 3.6 *Section through town centre re-development – Fire engineering design*

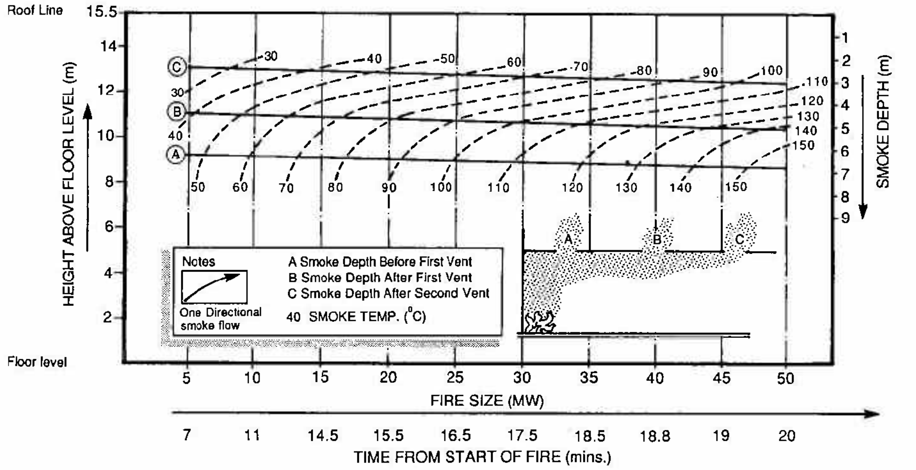


Fig 3.7 *Smoke control analysis graph – Basildon Town Square*

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Refurbishment at the Royal College of Art, London

Remedial Works
– Darwin Building, 8th Floor

Project Data

Consultants	Buro Happold
Contractors	Gordon Marshall Construction Ltd
Costs	£45,000
Contract Period	7 weeks at Christmas vacation 1986

The Royal College of Art was founded in London in 1837. The College's first home comprised of a few rooms in Somerset House. From there it moved to Marlborough House and later to a site just off Queens Gate. In 1863 it moved to premises adjacent to the Victoria and Albert Museum where some schools remained until the summer of 1987. In the early 1950's the College expanded to occupy houses in Cromwell Road, Queens Gate and Kensington Gore. Obviously the diversity of the properties was far from ideal and so in 1960 a much needed workshop and administration building was constructed next to the Albert Hall on Kensington Gore. Shortly afterwards a library, common rooms and a hall were built behind the workshop.

This is how the College remained until 1987 when it embarked on a programme of building contracts aimed at bringing all the schools together in the main Kensington Gore/Queens Gate site. The properties in Exhibition Road and Cromwell Road were vacated. In January 1987 Buro Happold became involved in the early stages of the programming of the various moves and planning of works necessary to accommodate them. Projects undertaken by Buro Happold included remedial works to the Darwin Building eighth floor and rationalisation schemes for the library, 23/25 Kensington Gore, Darwin basement and Darwin Building workshops. All works were held within a tight budget and had to be accommodated into an inflexible timetable, during college vacations.

Constraints on Time, Money and Information

Early work, as sole consultants, on a "package of works to improve the environment" at the eighth floor of the Darwin workshop revealed many of the difficulties which would be faced in the later more extensive programme of works. The most difficult engineering problems were not so much technical as to do with information and communication. Firstly, what structural and services information was already available for existing buildings? Secondly, what facilities did the College require in its development programme?

In spite of an extensive search by both the College and ourselves, no structural information could be found for any of the buildings on which we were to work. The only mechanical and electrical services drawings found were the original 1961 "as built" drawings of the workshop block. In the intervening years the internal arrangement, and consequently servicing of the building, had been greatly altered. In particular, the original central spine ducts for mechanical services and the modular trunking and lighting arrangement had been made redundant by the requirements of sophisticated workshop equipment and the replanning to accommodate it.

Uncertainties in the provisions within the programme for new equipment made it difficult to ascertain future services requirements whilst the sheer scale of the College's current equipment and staff resources added to these difficulties. Furthermore, as students work could not be interrupted, most of the building works had to be carried out during vacations. Consequently time, as well as money, was very limited, and design and contract periods had to proceed with information being added as it became available (Table 4.1).

The programming and budgeting of works had to be tailored to fit the overall funding and programme of funding if the projects were to go ahead. As a part of this exercise the overall programme was condensed. The building works to the workshop block were particularly affected, with the decision in March 1987 that all alterations should be carried out during the 1987 summer vacation instead of the 1987 and 1988 summer vacations as originally planned.

Remedial Works
– Darwin Building, 8th Floor

The eighth floor of the workshop building is mainly occupied by the School of Architecture whose accommodation comprises a series of studios, seminar rooms and offices. The floor was suffering from underheating in spite of works the College had carried out to the central heating system in recent years.

Buro Happold carried out a study of the thermal environment of the whole floor and recommended a package of works including new and replacement heat emitters, insulation of the structure, secondary glazing, and infilling of low level glazing (Fig 4.1).

Table 4.1 **Darwin Building Rationalisation**

1987

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Initial discussions & cost estimate	■											
BH given approval to appraise M & E Services		+										
Appraisal of M & E Services		■										
Programme condensed to one summer vacation			+									
Approval for design to tender stage given			+									
BH given approval to survey existing M & E Services			+									
M & E Services survey carried out			■	■								
Authorisation to proceed			■									
Architectural design period			■	■	■							
M & E Services design to tender				■	■							
Architectural and M & E Services continuing design						■	■	■	■	■		
Main contract tender period					■	■						
M & E Services tender period						■						
Assessment of tenders, authorisation to proceed and contractors mobilisation							■	■				
Contract period								■	■			
Post contract works with client in occupation									■	■	■	■

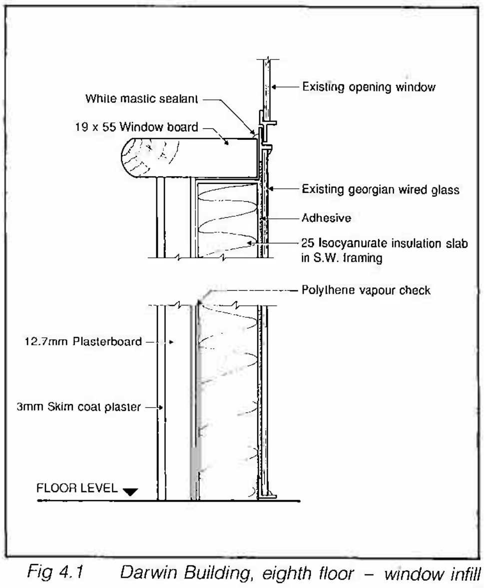


Fig 4.1 Darwin Building, eighth floor – window infill panel detail

Rationalisation Scheme – Library

Project Data

Architect	James Gowan, Royal College of Art Design Group
Structural and Services Engineers	Buro Happold
Project Manager	Dartington Management Services
Gallery Contractors	Metalix Limited
Minor Work Contractors	C W King Limited
Costs	£40,000 (Metalwork contract £25,000)
Contract Period	3 weeks at Easter vacation 1987

The College accepted the recommendations, and commissioned us to carry out all the necessary design work and to obtain competitive tenders. On receipt of these, a programme was agreed and the contractor carried out the work under supervision in the Christmas vacation 1986. The final cost fell within the budget for the works and well below budgets previously prepared by other parties.

Conditions of occupation in the colder winter period of 1987 bear witness to the considerable improvements made, enabling studio work to continue uninterrupted, which had not previously been possible.

Rationalisation Scheme – Library

As part of the bringing together of the college, work had to be carried out to increase the capacity of the library. This comprised some building works to relocate internal walls, associated building services alterations and the extension of a gallery of bookshelves and walkway. Work on the gallery accounted for approximately two thirds of the cost of the library alterations. The interior design of the original 1960's buildings had been consistent throughout and the alterations to the library needed to remain in character and match the original metalwork in style. There were two short sections of high level shelving against walls, with access from walkways and spiral staircases up from ground level. The concept was to link these walkways and extend them around a greater length of the perimeter of the room (Fig 4.2).

Structural Elements

The original structure was an unusual mixture of load bearing masonry and reinforced concrete frame. As there were no as-built drawings and little clarity to the existing structure, it was difficult to make assumptions about the various structural elements. Furthermore whilst the library was in use, it was only possible to make small exposures in the finishes, to investigate these elements.

The original galleries were supported from cast-in fixings in the edge beams of the ribbed concrete roof slab and the shelves were fixed to the walls. Where possible, this system was extended; however, full height windows into the courtyard meant that the new shelving could not be fixed to the walls in some areas (Fig 4.3). To maintain an appearance consistent with the original, and to provide a feature when viewed from outside, the supports to shelving and galleries were suspended in the area adjacent to windows. To minimise additional loads on the roof, steel trusses located between book stacks were used to span between columns (Fig 4.4).

Metalix, metalwork contractors experienced in shop-fitting, were appointed to fabricate and install all the galleries, shelving and associated electrical work in the 3 week Easter vacation period. The tender price was a fixed sum but based on preliminary design drawings. As soon as the library was out of use for the holiday period, extensive exposures were made in the ceiling and walls which showed that the structure varied even more than had been assumed. Rapid final design was carried out to suit the differing support details required for the various areas. Hanger positions had to suit the geometric arrangement of the gallery and could not easily be adjusted to suit the structure as found from the exposures. Fixings had therefore to be designed for solid concrete, light weight blockwork and clay pots, and many types were used.

The project was successfully completed maintaining the style of the original library and enabling the library to be back in use for the beginning of the summer term.

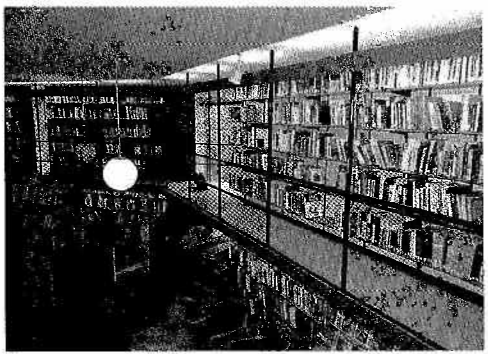


Fig 4.2 High level galleried shelving of library

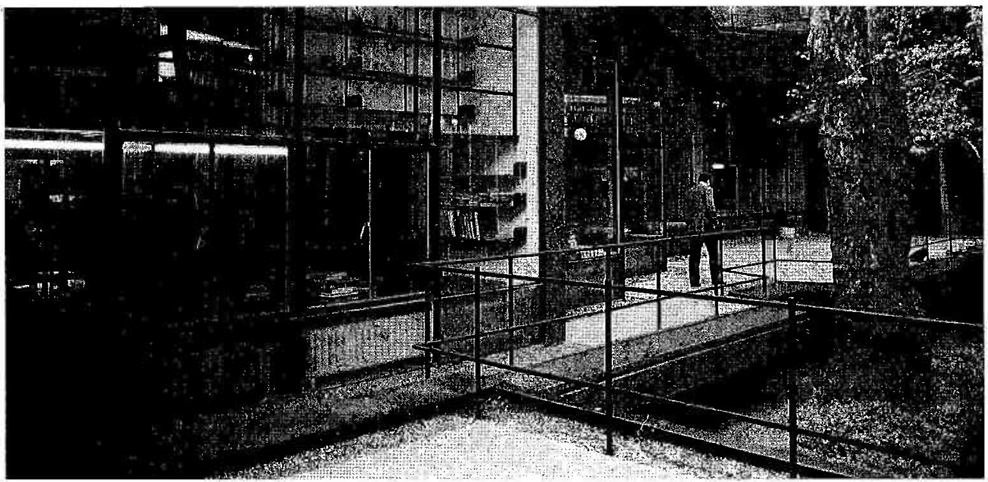


Fig 4.3 Library shelving seen from courtyard

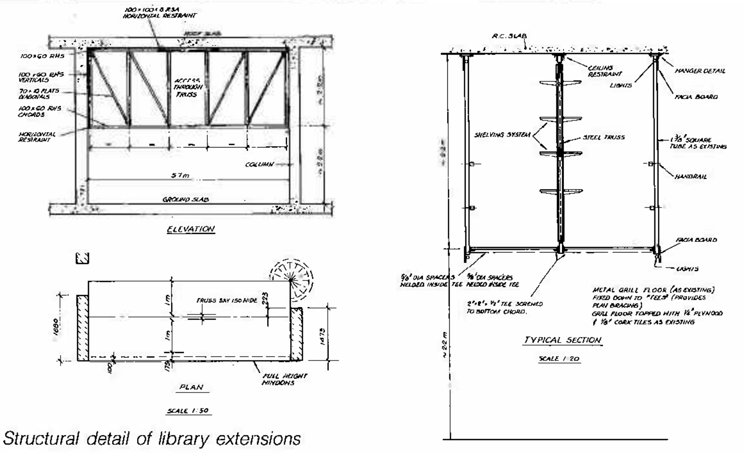


Fig 4.4 Structural detail of library extensions

Rationalisation Scheme – 23/25 Kensington Gore and Darwin Basements

Project Data

Architect	James Gowan, Royal College of Art Design Group
Services and Structural Engineers	Buro Happold
Quantity Surveyors	Davis, Bellfield and Everest
Project Manager	Dartington Management Services
Contractors	Westgate Construction Ltd
Costs	£225,000
Contract Period	11 weeks, summer term 1987

Rationalisation Scheme – 23/25 Kensington Gore and Darwin Basements

Work was carried out under the rationalisation scheme to accommodate mainly the Graphic and Photographic Schools on a temporary basis, after the disposal of premises in Cromwell Road. These schools were to occupy three houses, Nos 23, 24 and 25 Kensington Gore and part of the basement in the main Darwin Building for only two years. The three houses were in a very rundown condition and whilst the large rooms provided suitable studio spaces, they did not easily accommodate the large number of small dark rooms required. The dark rooms were located in the basement of No 25 and the basement of the Darwin Building.

Unusual Service Design Parameters

The planned short life of occupation meant that normal design parameters were not appropriate. The prime consideration was to safely meet the requirements of the users within a very low capital cost target, re-using existing College equipment where possible. The Client's needs were met by:

(a) Electrical rewiring of some floors only
(b) New lighting schemes, reusing Client's dark room fittings where possible
(c) Extending and adapting existing hot and cold water installations and wastes and drains
(d) Provision of electric heating, reusing Client's heat emitters
(e) Local extract ventilation, reusing Client's wall mounted extract fans where possible with the addition of new darkroom units
(f) Local comfort cooling reusing Client's air conditioning equipment
(g) Provision of a new water storage and supply system to serve darkrooms in 25 Kensington Gore.

The large quantity of water used each day by the photographic department was found to be far in excess of the daily supply available from the Water Authority mains, and existing storage in No 25 was adequate for domestic purposes only. The problem was overcome by providing a separate distribution pipework system to the dark room sinks, this being from a new 24m^3 sectional storage tank located in the back garden at No 24 Kensington Gore.

The College departments were able to occupy the buildings and release their former premises to new owners on time as planned.

Rationalisation Scheme – Darwin Workshops

During the summer vacation major works were carried out to the Darwin Building to bring various departments together on one floor and to introduce other departments into the building from other premises. Building and associated mechanical and electrical services works were carried out to selected areas of the second, third, fourth, seventh, and eighth floors of the Darwin Building. The first, fifth and sixth floors were completely internally stripped out, rebuilt and reserviced (Fig 4.5).

Mechanical services design work was carried out on the many various extract systems; air, steam and water supply; and on general and special wastes and drainage. Electrical involvement included work on single and three phase power; general, task and emergency lighting and on fire alarms and equipment controls.

Structurally, design work was necessary for partition fittings, mechanical services supports, mezzanine floor steelwork, and the installation of an internal staircase, due to the complete absence of structural drawings. Further work involved load testing advice on the sixth floor to establish a minimum floor capacity.

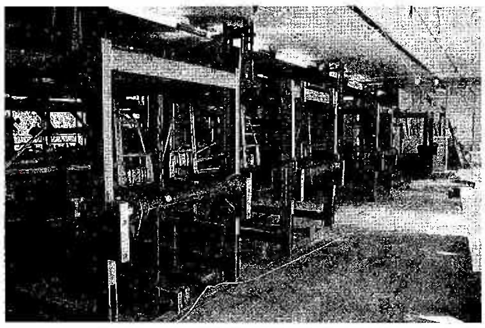
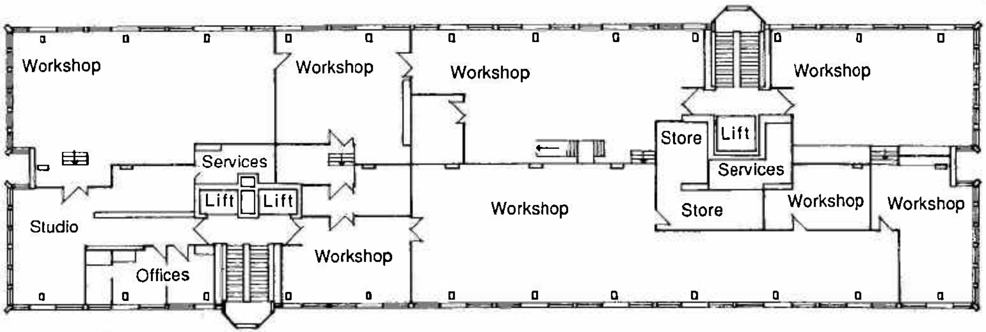


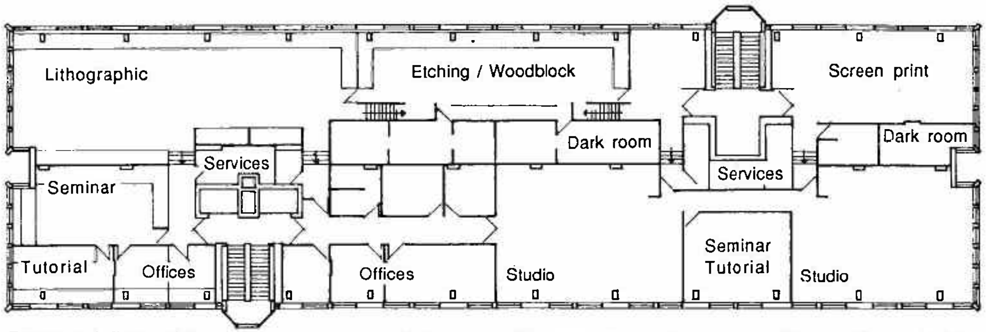
Fig 4.6 Original jacquard looms from Darwin Workshops

Continuing Design

As well as conventional internal partition construction and normal servicing and lighting, the contract included the disconnection, movement and re-installation of the College's existing workshop equipment and the supply and installation of much new workshop equipment (Fig 4.6). Almost all of this equipment required electrical services, while much of it required various mechanical services. To further complicate matters some items of equipment were "one off" purpose made, some were constructed on site and with some the final services requirements were not known until they



Existing floor plan



Proposed floor plan

Fig 4.5 Existing and proposed floor plan – 6th floor Darwin Building

Rationalisation Scheme – Darwin Workshops

Project Data

Architect	Peter Barker, Royal College of Art Design Group
Services and Structural Engineers	Buro Happold
Quantity Surveyors	Davis, Bellfield and Everest
Project Manager	Dartington Management Services
Main Contractors	Myton Ltd
Services Sub-Contractors	Drake and Scull Ltd (Special Works Department)
Costs	£1.3m
Survey and Design Period	10 weeks
Contract Period	11 weeks at summer vacation 1987

were in position on site. Thus design had to continue through to the last week of the contract. Although the building's existing services had been surveyed, with the time parameters imposed and the inaccessibility of certain areas, some design and redesign inevitably had to be carried out on site.

The finished building services design therefore evolved during a period starting with the architect's drawings, spanning the contractor's tender periods, tender appraisal periods and including the period of work on site itself. In the event even this design was not final. When the building was handed back to the College, the departments asked for a variety of additional architectural and building services works, most requests resulting from the users experience in their new workshops. The additional works were carried out as a continuation of the contract with all departments continuing in occupation and functioning normally.

Limits Imposed by Budget

The budget limitations precluded the replacement of much of the building's old and unreliable plant and equipment. Money was found however to replace all the electrical mains distribution boards between 1st and 8th floors as the existing system did not meet current regulations regarding safety (Fig 4.7a,b,c). Rather than replace the entire cubicles the services sub-contractor opted for stripping out the existing ones and refitting them in-situ.

Unfortunately finance was not available for re-furbishing the passenger and goods lifts which are not operating correctly and require considerable ad-hoc maintenance to keep them running. The College's financial constraints dictate that the capital required for a major refurbishment of the lifts will not be available until summer 1989 when it is intended the work will be carried out.

Work on Ventilation Systems

In common with the lifts, the College's extract ventilation systems are more than 25 years old. There are some fifteen main separate extract systems as well as local ventilation plants. The main systems are for general ventilation, cellulose extraction, dust extraction, fume removal, heat removal, acid fume extraction, and lavatory extraction. With no central supply air plant, the building is obviously designed to allow a high degree of infiltration but with so many different extract systems competing with each other it was, and indeed still is, difficult to predict accurately the movement of air within the building.

A particular difficulty arose with the system extracting air from a new canopy hood over new glass furnaces within the School of Glass and Ceramics at 1st floor level. The existing system did not perform as predicted and extracted only half the volume of air anticipated. This led to complaints from the users that it was too hot in the room (Fig 4.8). The old extract ductwork, insulated with asbestos, had been sealed by the College a few years earlier, and incorporated no test or access holes whatsoever, even at fire damper positions. The package of works necessary on this system included asbestos removal, provision of access facilities, replacement of flexible connections and the fitting of a replacement motor and pulleys to increase the speed of the fan. Following the successful uprating of the fan, recommendations were made identifying ways in which the working environment in the kiln room could be further improved. The users opted to implement the main proposal involving the use of insulated screens to prevent the radiant heat from open kilns, firing at 1000°C, escaping into the working area (Fig 4.9a,b,c).

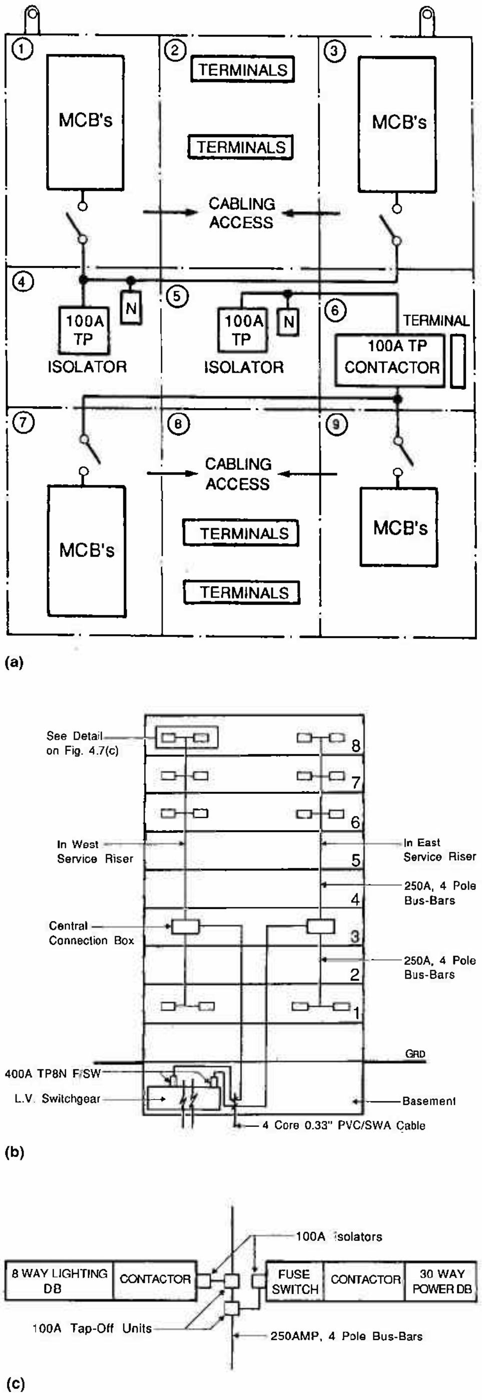


Fig 4.7 (a) Typical distribution board layout (NTS) (b,c) Section through Darwin Building, schematic distribution

Structural Design – Load Testing

Because of the lack of hard information on the design and detail of the existing structure, it was not initially possible to make anything other than assumptions based on engineering judgement about the load-carrying capacity of the floors.

On the 6th floor it was planned to install printing presses in the south east corner of the building. These machines would load the floor more heavily than it had been loaded previously and further investigation of the capacity of the floor was necessary.

The choices for further investigation were either to take cores and make other exposures and investigations to determine the details of the structure, or to carry out a load test. As the increased loading was in a limited area of the building, it was decided that a load test was most appropriate.

A uniformly distributed load was calculated which would be equivalent to the line loads applied by the printing presses. Cast iron weights were used as kentledge to incrementally load the floor to 4kN/m^2 maximum superimposed load. Deflection measurements were made using 12 transducers mounted on a safety scaffold placed beneath the slab (Fig 4.10).

The results of the load test were satisfactory, fully complying with the requirements of BS8110. The printing presses were installed successfully.

Although the works on site continued beyond vacation time to cater for the users' new requests, the main works were successfully completed to allow the College to commence the autumn term on time. A total of £1.3m worth of work was carried out in an existing building in 11 weeks. This would not however have been achieved without full commitment and flexibility on the part of both the designers and the contractors involved in the project.

Peter Brooke, Richard Harris and Din Patel

Fig 4.8 Glass furnace room – Darwin Workshop

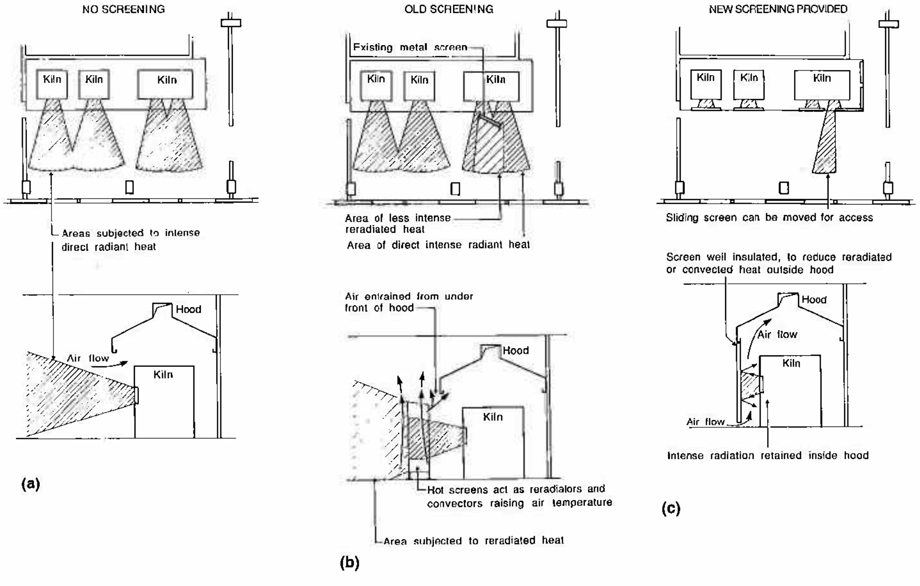


Fig 4.9 (a,b,c) Use of screens in the Kiln room

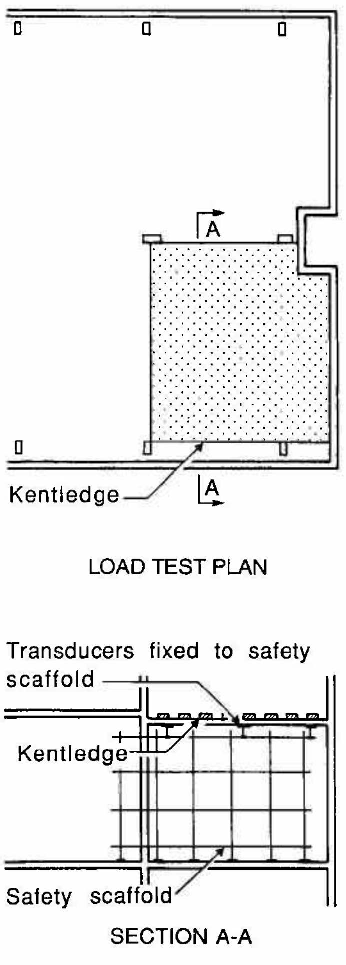


Fig 4.10 Section and plan of load testing on the 6th floor

Butter Process Plant for Anchor Foods, Swindon

Project Data

Client	Anchor Foods Ltd
Architect and Quantity Surveyor	Wyvern Partnership
Consulting Engineers	Buro Happold
Contractor	Sir Robert MacAlpine
Built Area	19,000m^2
Date	1979
Cost	£8.6m

Our appointment for this butter process plant arose from a chance meeting between Peter Buckthorp and Alan Watson, a partner of the architectural practice Wyvern Partnership, at a Cement and Concrete Association technical meeting. They held similar views on team working and particularly on services engineering within the building industry, and each made a mental note to look for a suitable opportunity to work together.

A short time later Anchor Foods Ltd, who had been considering selling their existing premises in the London docks, started to search for a larger site in Swindon. The Anchor Foods management had obtained a list of all Swindon architects and on a Friday afternoon decided to call each practice in alphabetical order asking to speak to a partner. The responses they received included "the partners were out" or "not available" and as a consequence they passed to the next practice on the list. Alphabetically Wyvern were the last firm. When the call came in they responded immediately and that night two of their partners met with representatives of Anchor Foods in Bristol to agree the contract. Fortunately Alan Watson recalled the earlier conversation and the opportunity for his and our practice to work together was available.

In November 1977 the team was appointed for the design of a 17,000m^2 butter processing plant. The plant had to be operational in 23 months, by October 1979, to coincide with new EEC ruling concerning the importation of butter from New Zealand. To meet the date the contractor had to be given the maximum construction time possible. A start date of May 1978 was set, with a planning submission in April. The design team had just 5 months to prepare the contract documentation for what at that time was a £5 million contract. A present day equivalent would be of the order of £10m.

Requirements of the Plant

The butter arrives from New Zealand in refrigerated containers as unsalted blocks each weighing 1000 kg. After transportation from the docks it is held in the cold store until required for processing and packaging to the familiar form. The plant consists of a 28,300m^3 cold store for 10,000 tonnes of butter stored at −10°C, a 6,800m^3 cheese store for 750 tonnes of cheese at 9°C and a 4130m^3 packed butter store at 5.6°C.

After storage the 1 tonne blocks of butter are moved to conditioning rooms where the temperature can gradually be raised from −10°C to 0°C when it is then suitable for processing. At the processing stage the butter is moulded, with water and salt being added to EEC limits before wrapping. The processing block receives many visitors each year and is provided with a viewing gallery (Fig 5.1) linked by a bridge to the main office block. The refrigerated butter is delivered at the western goods-in loading bay and after passing through the plant leaves by the goods-out dock on the eastern side of this site. The complete layout of the process plant is shown in Fig 5.2.

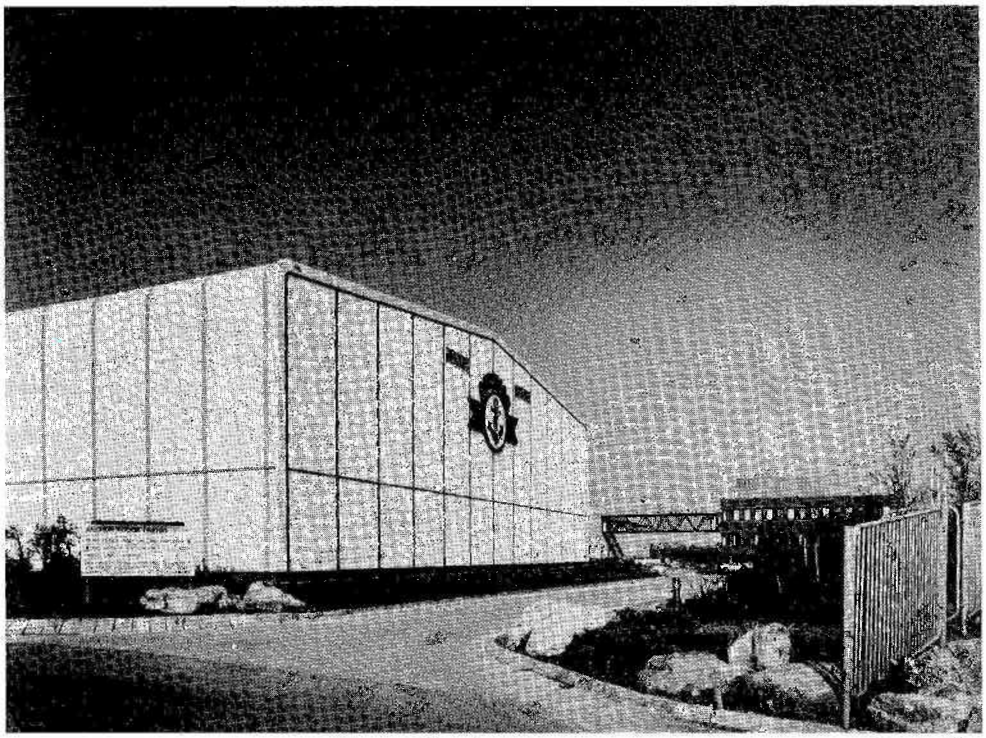


Fig 5.1 *Entrance to Anchor Foods showing cold store and head office facilities*

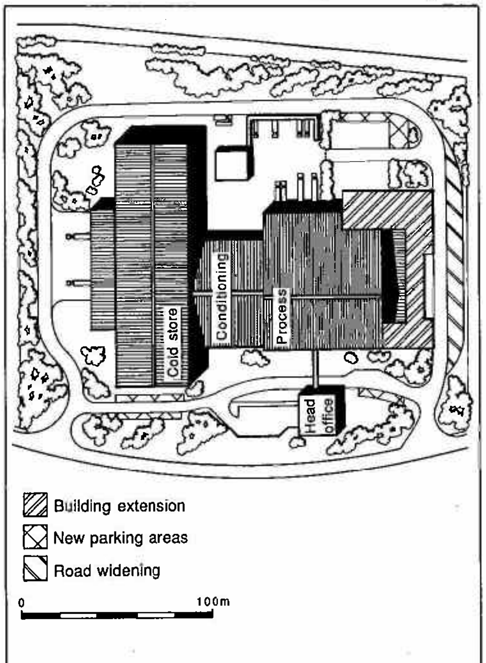


Fig 5.2
Layout of process plant site with 1985 extensions

Design of Cold Store

The design of the cold store presented several interesting problems including:–

(a) the design of a floor to support 65 KN/m^2
(b) the design of a 126m long building without expansion joints
(c) the design of a structure to withstand an environment of −20°C internally and +25° to −10°C externally.

The floor was to support butter stacks, which produced floor loadings in the order of 65 KN/m^2, as well as fork lift trucks in the aisles. Whilst the locations of the butter loads are well defined they are continually applied and removed on a weekly cycle. It was therefore important to ensure that any insulation material would not deform excessively by creep or elastic movements.

After a series of studies the floor construction as shown in Fig 5.3 was adopted. The floor of the

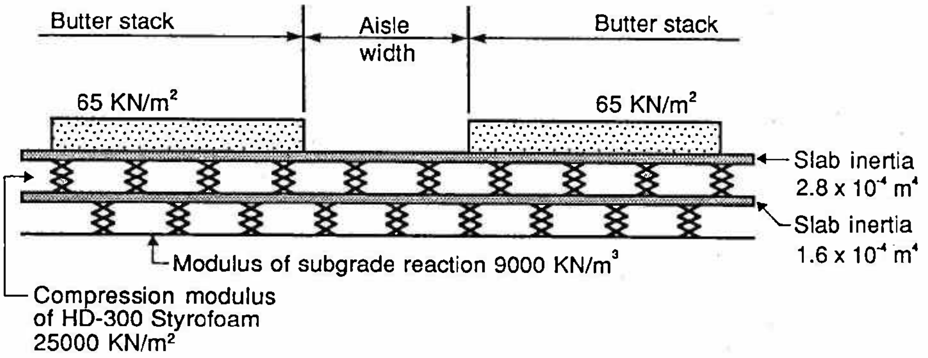


Fig 5.3 Mathematical model of cold store floor

coldstore was insulated with 125mm of heavy duty styrofoam. The formation of frost beneath the floor was a potential problem in the butter cold store and so beneath the styrofoam a heater mat was provided to keep the sub-floor temperature at 3°C. The mat comprised 21mm diameter low density polythene tube laid in continuous coils at one metre centres. A solution of glycol was circulated through the coils, the heat for the glycol being obtained through a heat exchanger which used waste heat from the butter cold store refrigeration plant.

A mathematical model of this system was established to link the subsoil and styrofoam, and the complete system was analysed as slabs on a series of springs. In that way it was possible to study the combinations of adjacent butter stacks, fork lift trucks, the effect of rigid supports such as the edge beams and the influence of the spacing of the longitudinal joints. Only limited design guidance was available to engineers at that time as this was prior to the 1982 report by the C & CA on the design of ground slabs. It was satisfying to find later that the C & CA method produced results which were virtually identical to that adopted by our approach (Fig 5.3). A 40 N/mm^2 concrete with silica sand was used for the upper slab and 30 N/mm^2 concrete for the base slab. The slabs were cast using the long strip method to minimise construction joints, and all joint positions were specified on the drawings.

The design of the building frame posed further problems. A height of 11.5m at eaves and span of 40m, coupled with an overall length of 126m presented a major difficulty in ensuring adequate rigidity under wind loads. Thermal movement was an additional problem. The solution adopted for the cold store was to provide a horizontal truss in the plane of the lower chord whereby the wind forces were transmitted to the ground at the mid point of the gable walls and at the ¼ points along the elevations from each gable wall (Fig 5.4 a,b). That solution provided 6 frames able to transmit wind forces to the ground, 4 of which were also capable of resisting thermal stresses. Obviously no bracing system is 100% efficient and in considering the overall sway of the structure the rigidity of the bracing was considered as a stiff spring and was appropriately analysed.

Having established the engineering skeleton, the cladding and insulation were then considered. A choice existed between external insulation and insulation within the structure. To insulate externally was attractive since it could also be utilised as the building cladding. The disadvantage of steelwork exposed to −20°C is that the risk of brittle fracture is increased. Steels normally available in Britain are suitable for temperatures down to −15°C provided that reduced stresses are adopted. The application of lower temperatures commands either the adoption of very low working stresses or the use of special grade steels with a high Charpy value, which is a measure of the energy steel can absorb at low temperature before cracking.

Internal insulation was however finally agreed upon and produced a clean lined internal surface. The insulation for both walls and ceilings consisted of 200mm thick polyurethane faced with 22g galvanised sheet steel coated with plastisol. Profiled colour coated steel cladding by Floclad was used externally.

The roof space between the trusses was used for access and the distribution of the major services runs. All steelwork was protected in accordance with BS5493 which in this case was achieved using a zinc spray plus sealer.

Design of Process Block

The process block has an overall area of 6000m^2 and contains the butter packing hall which is 64m × 21m in plan. The column grid is basically 13.75m × 8.4m although the butter hall has a clear span of 21m. The process hall was designed as a 2 storey propped portal with a design floor loading of 5 KN/m^2. On the ground floor there is a packed butter store and dry goods warehouse. The first floor consists of storage, offices, laboratories and was designed using continuous composite construction.

At that time continuous composite design was in the process of evolution. The methods adopted in Swindon have now in many respects been incorporated in the new European Code of Practice with contributions made from the practice through John Morrison as Chairman of the British Committee. Up until then the only method available was simply supported design but it was appreciated that if top reinforcement was provided at the supports then a degree of fixity could be achieved which would reduce steel size and weight without sacrificing the stiffness of the structure.

Another interesting feature of the process plant is the visitors viewing gallery (Fig 5.5) at 1st floor which permits visitors to look down through glass screens to see butter blending and packing in the main hall. The gallery screen is an inclined glass wall divided by inclined mullions which also support the cantilever from the roof structure above. The deflection limits of this complete system under snow, wind and live loads had to be carefully studied to ensure that there was no excess deflection which could distort and crack the glazed screen. The structural form was initially designed as a two-dimensional frame with the corners checked as a three dimensional structure.

Access to the viewing gallery is via the bridge link over the access road between the office and process blocks. The link bridge is an enclosed structure and is also a major architectural feature. It was designed as an exposed Warren girder using rectangular hollow sections with a fixed joint at one end and a free movement joint at the other. The trusses were welded off site and then joined at the roof and deck levels on site to give a dramatic link between office and production areas.

External Works

An external ring road was required as well as substantial hard standing for cars. Maintenance workshops and cleaning facilities for the transport fleet completed the engineering complex.

Beyond the road it was a requirement of the planning approval that the development should be enclosed by an embankment. The client specified that the embankments be covered with plants from New Zealand and, to minimise land usage, that the banks should be as steep as possible. These factors presented several problems. The banks had to be formed using excavated material, in this case Kimmeridge clay, which is notoriously unstable. The landscape architect could not permit the banks to be compacted as that would limit plant growth. A compromise was adopted whereby the remoulded clay strength parameters were used for the embankment design and compaction limited to that produced by the draglines depositing the fill.

Subsequent Works

After the complex had been established for several years Anchor Foods Ltd required extra facilities for new ventures and further expansion.

In four phases and over several years we have substantially widened roads to enable supplementary lorry turning and further car parking. To achieve road widening a long section of the embankment was removed requiring the construction of a retaining wall and diversion of major services. Then followed the addition of the creamery complex to manufacture pressurised spray cream. In addition to executing the structural design, we provided the quality assurance monitoring of the services engineering. An assembly area was added at that time as well as a new fully enclosed loading dock to serve the new product line.

Most recently Smith and Partners were commissioned under a package deal to provide an extension to the chill store and they retained us for the engineering design. Further significant maintenance works and modifications are carried out from time to time on the site.

John Morrison/Peter Buckthorp

Fig 5.5 Main hall seen from 1st floor visitors' gallery

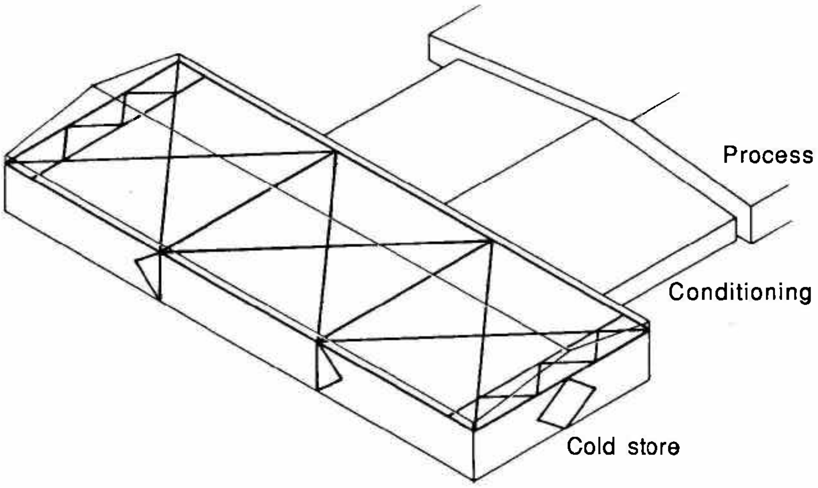


Fig 5.4a Cold store – diagonal steel bracing

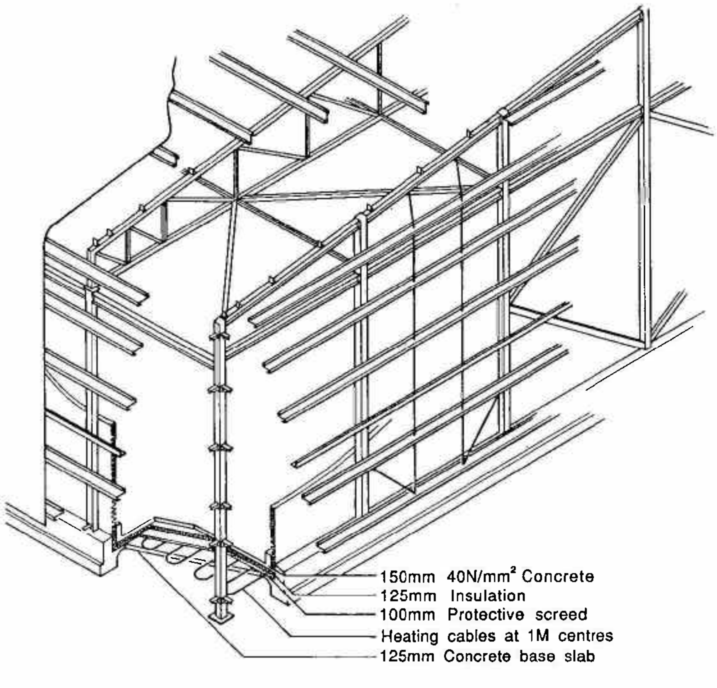


Fig 5.4b Detail of gable end wind bracing

Wellsite Engineering

Project Data

Client	Tricentrol Oil Exploration
Project Management	Wellsite Management Ltd
Civil Engineering Design and Supervision	Buro Happold
Civil Works Contract Value	£200 000
Contractor (Civil)	Archibald Russell of Denny Ltd
Contractor (Drilling)	ITM
Date	1986

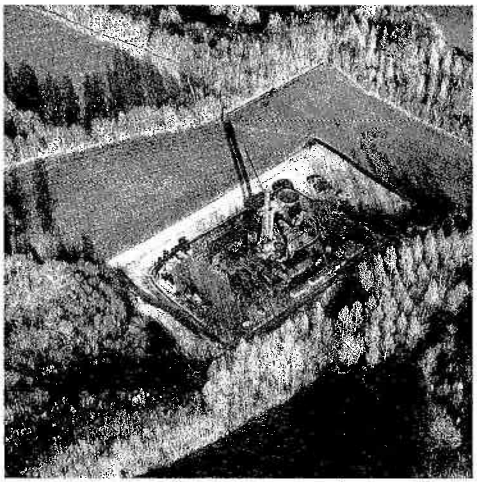


Fig 6.1 The wellsite in the landscape

Escalating oil prices bringing a five fold increase in the price of crude oil, led in the 1970's to a critical evaluation by Western Block nations of alternative energy resources, resulting in the exploitation of North Sea oil fields and the development of onshore oil resources in the UK.

At this time the Department of Energy began awarding onshore exploration licenses, with such fossil fuel reservoirs estimated to offer 5–10% of total UK oil requirement. Best prospects for exploration lie in the southern counties of Dorset, Hampshire, Surrey, Sussex and Kent, with well established fields at Wych Farm, and Kimmeridge in Dorset and at Eakring in Nottinghamshire.

However, onshore exploration and production brings difficulties not encountered offshore, with environmental and planning aspects a key consideration and many applications for wellsites have failed on these grounds.

Development of the Wellsite

There are three phases concerned with onshore drilling – exploration, appraisal and production.

During exploration and appraisal the wellsite, a little larger than a football pitch in area, is constructed, drained and fenced and provided with access and usually power (Fig 6.1). Two wells are generally drilled from each site, to verify preliminary seismic survey data.

If results are favourable, then monitoring for production viability is carried out over several months. Only small scale monitoring equipment is held on site at this stage.

Fig 6.2 Drilling rig used during exploration phase

Following this appraisal, the decision on whether to proceed with production is made. A positive decision involves the extension of the original wellsite with the drilling of a production well, and the probable construction of further production wellsites in the locality (Fig 6.2). A gathering and distribution station comprising a tank farm, purification plant, administration facilities and loading facilities will also be required.

At each of these phases separate applications for planning permissions for mineral extraction are required, often proving lengthy, with environmental impact a major consideration.

Wellsite Management and Buro Happold

In 1985 Buro Happold were approached by an onshore project management organisation, Wellsite Management, to assist with engineering expertise and back-up for onshore wellsite development.

An initial study highlighted areas for engineering involvement in site selection and evaluation, planning aspects, environmental appraisal and impact (Fig 6.3), site investigation and topographic survey, preparation of site layout and civil works details, preparation of contract documentation, tendering of contract and supervision during construction and site reinstatement should the exploration wellsite prove unsuccessful.

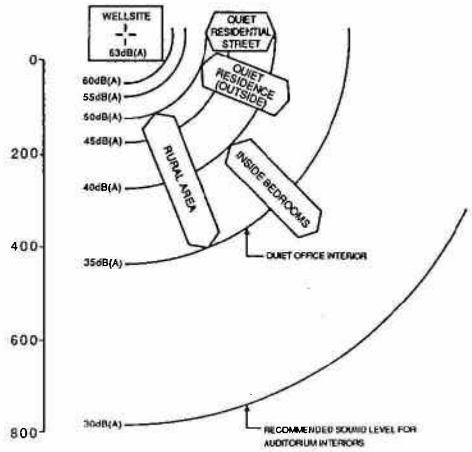


Fig 6.3 Noise levels from typical wellsite

During this study certain areas where further research might prove profitable were also identified including the evaluation of various temporary surfaces to the wellsite such as grid confinement or linked block paving systems.

Wellsite XL162, Inch of Ferryton, Scotland – An Example

In the autumn of 1985 Wellsite Management and Buro Happold were commissioned by Tricentrol Oil (Exploration) Limited to project manage, design and supervise construction for a wellsite in Scotland. This site, in exploration block XL162, was located on the left bank of the River Forth in the flood plain near to the town of Clackmannan, and situated on a tenanted farm known as the "Inch of Ferryton". The exploration wellsite, although fairly simple in concept, contained many of the aspects and difficulties anticipated in the earlier study carried out with Wellsite Management.

At an early stage it became clear that the planning authorities would not allow either construction traffic for the wellsite, or traffic bringing the rig and its associated equipment to the site, to pass through the village of Clackmannan. Consequently, it was necessary to route all construction and rig traffic along a minor road near to the Kincardine power station (Fig 6.4). This road fell under the jurisdiction of both the East Fife Region and Central Region Highway Authorities, both of which required extensive highway improvements to be carried out before construction or rig traffic could be permitted to use the road. These works involved the provision of passing places for heavy vehicles, strengthening of culverts, and improvements to ditches and road drainage generally.

The wellsite was located in a farm field given over to winter barley, but at a level susceptible to flooding and indeed lower than the flood level of the River Forth itself. Information from the farmer working the land, the flood records of the River and Local Authorities and those of the Clackmannan District Council, were also examined. From these investigations it was decided that the wellsite would be constructed on a fill platform, some 1.5 metres in depth to raise the working level above the flood plain and to provide distribution of imposed loads and equipment to the underlying ground. From a trial pit site investigation carried out for Buro Happold by Messrs Harry Stanger, it was established that the material below ground comprised silts and clays, and was susceptible to consolidation in certain circumstances. In order to avoid differential settlement and consequential tilting and misalignment of the drilling rig, a 1.5m thickness of fill was used together with bearer pads for the drilling equipment, to distribute the load to the existing formation.

The Forth River Authority were concerned about the possibility of chemical or oil spillage and pollution of watercourses. However, an interceptor was used at the position of outfall for wellsite surface water draining in to a local stream, so removing the possibility of pollution. A further problem lay in the close alignment of the site with an existing overhead 275 KV electricity transmission line and it was necessary to precisely locate the rig position, and hence the wellsite, to conform to clearance criteria defined by the Scottish Electricity Generating Board (Fig 6.4).

The wellsite layout was developed together with other detailed designs incorporating the construction and the necessary road improvements. These were then presented in an ICE 5th Edition Contract and tendered to three contractors.

A local company, Archibald Russell of Denny, who had carried out similar wellsite developments for others in the region, were the successful tenderers. Work started in January 1986, and the wellsite was available for occupation by the drilling contractor by the end of February. As the civil works contractor completed minor finishing works the drilling contractor brought the drill and associated equipment to site, involving some 50 heavy duty vehicle movements. This activity was closely co-ordinated with the finishing of civil works. After approximately a week, equipment assembly was completed and run up. Drilling then commenced and proceeded for approximately three months. Two wells, one vertical and a second deviating to the north east, were drilled. The appraisal phase will be initiated shortly, on receipt of planning authorisation.

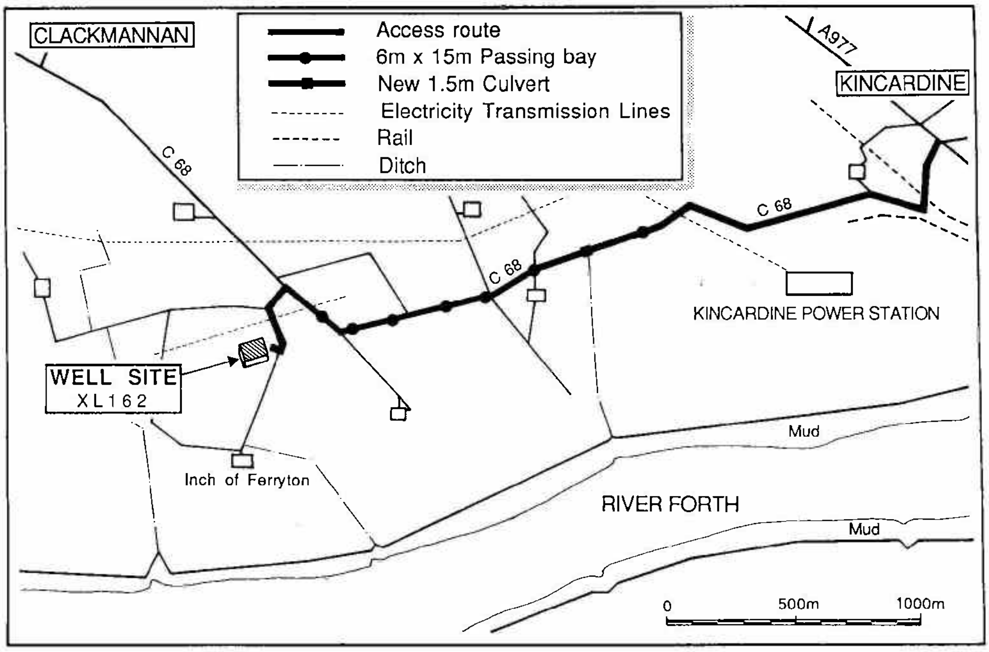


Fig 6.4 Access route to wellsite

The Present Situation

The fall in oil prices during 1986 caused a slowing in investment in onshore drilling, with a particular slump in exploration. Operators preferred to concentrate on maximising returns from existing production facilities and minimising non-essential expenditure. Certain projects however, including Humbly Grove in Hampshire (Carless Oil) and Welton in Lincolnshire (BP) have gone forward and are now in production. With the moderate recovery in oil prices, it is expected that interest in onshore exploration will revive within the next 12 months. Currently, Wellsite Management and Buro Happold are preparing to work with the Scottish Development Agency and Eco Drill to determine the feasibility of a permanent training onshore wellsite near Aberdeen. Such a site would offer all the features of an exploration and production wellsite for 'hands-on' training of drilling personnel.

Vincent Grant

Community Buildings under "Westway", London

Project Data

Client	North Kensington Amenity Trust
Architects	Franklin Stafford Partnership
Structural Engineers	Buro Happold
Services Engineers	Buro Happold, Dale & Goldfinger, Brian Warwicker Partnership
Quantity Surveyors	Boyden & Co, White & Turner Dauncey Linde Mellstrom & Bass
Costs	See table below

In the late 1960's the Western Avenue Extension, "Westway", was constructed to connect the A40 to central London. This elevated motorway cut a swathe through the residential areas of North Kensington. Local concern about the adverse effects of this scheme led to the setting up in 1971 of the North Kensington Amenity Trust (NKAT) to develop the space beneth the motorway for the use and benefit of the local community (Fig 7.1). NKAT commissioned Franklin Stafford Partnership to undertake the planning of the land use and subsequent architectural design of a wide range of industrial, commercial and recreational buildings within this space.

Buro Happold have been involved for almost ten years in the design of the structure and engineering services for many of these buildings. All of these projects have presented a unique engineering challenge in attempting to construct small scale buildings underneath a massive highway structure.

Structural Design

All new structures were independent of the motorway structure but as close as possible to it to maximise the usable space (Fig 7.2). Foundations were generally pad footings on the firm London clay, many being adjacent to existing pile caps. However, where ground conditions were bad due to the existence of large amounts of fill or basements and footings of old houses, then reinforced concrete rafts were used. Foundations also had to take account of motorway drainage pipes which contain extremely high water pressure jets during cleaning of the highway above.

Many of the buildings required door and window openings to be cut through the 533m thick reinforced concrete support walls. This was achieved by diamond drilling or sawing and dropping the blocks of concrete, sometimes weighing up to 4 tonnes, onto the ground below.

Project Cost Data

Project	Value £	Size m^2	Completed	Main Contractor
Totters Yard – Stables & Workshops	75,000	1,200	1979	H. Fairweather & Co Ltd
Maxilla Print Workshops	200,000	500	1980	R Schooley & Son Ltd
Acklam Workshops	300,000	2,000	1980	Burlingway Const. Ltd
Acklam Playcentre	165,000	500	1980	Burlingway Const. Ltd
Ilea Sports Facilities	275,000	450	1982	Miller Buckley Ltd
Portobello Green	1.5m	3,500	1982	Wiltshier Ltd
Bramley Road Shops	150,000	350	1982	B. W. Edwards & Son Ltd
Portobello Green – Landscaping	200,000	600	1985	B. W. Edwards & Son Ltd
Acklam Hall Refurb	135,000	500	1985	Wiltshier Ltd
Fitness & Snooker Centre	0.9m	1,300	1988	Moss London Ltd
Training Workshops	0.9m	2,100	1988	Moss London Ltd

Fig 7.2 Market canopy located adjacent to Westway structure

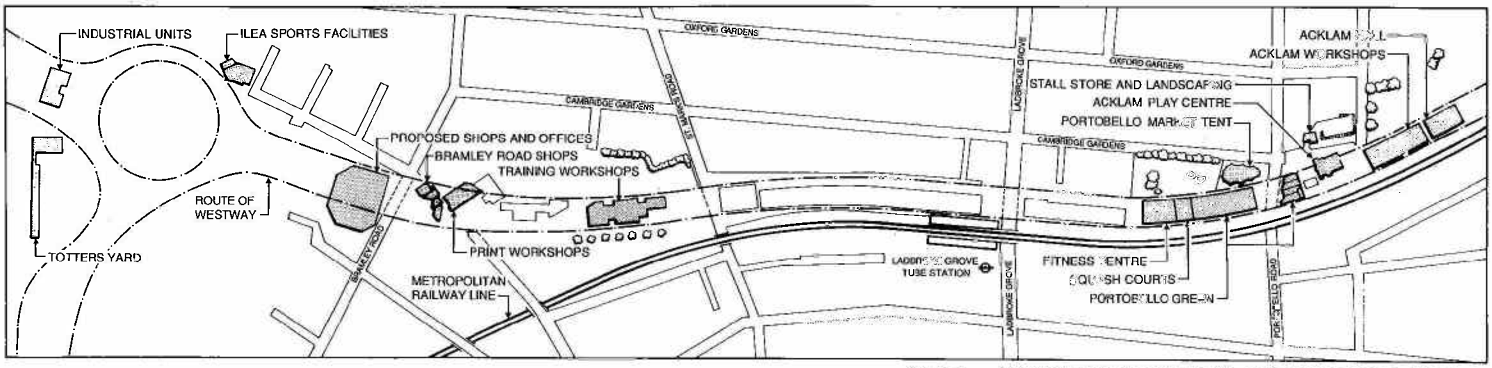


Fig 7.1 Location of community buildings beneath route of Westway

In the eastern part of the development the simply spanning precast concrete highway deck has been used as the roof of the building without any special fire protection applied. In the western part the continuous prestressed concrete structure has required that all the buildings have a one hour fire resisting roof structure or that fire resistant material is applied to the soffit of the motorway deck.

While the vertical deflection of the highway deck is minimal, the prestressed section can move laterally by up to 200mm so any connection detail between the new structures and the deck soffit had to be designed to accommodate this. One of the owner's preconditions of allowing these buildings was that there should be access to inspect the bearings. Should a bearing require replacing then the deck will be jacked-up off either the columns or access scaffolding erected from ground level. During the design of these projects consultation took place between the designers and the owner of the motorway, previously the GLC and now the Department of Transport, and London Transport, as many of the buildings are adjacent to the retaining wall supporting the Metropolitan Railway Line.

Development of Individual Projects

Our first project was the "Totters Yard" scheme for local rag and bone merchants (Fig 7.3), which comprised a steel stressed skin roof on loadbearing masonry walls. The next scheme consisted of a playcentre constructed of lightweight precast concrete roofing and in situ concrete flat slabs on loadbearing walls, with industrial workshops constructed of "waffle" slabs on reinforced concrete columns.

The next and most ambitious project was the Portobello Green development comprising offices, shops, workshops, social and recreational facilities. The structure generally comprised a mezzanine floor 350mm deep with hollow clay pots spanning up to 9.6m supported on square columns on pad footings. As the Portobello Road street market was displaced by the development, NKAT commissioned the erection of the Portobello Market Canopy, a PVC coated polyester membrane tent structure adjacent to the site for use by the market (Fig 7.4). This tent now provides a focal point in the annual Notting Hill Carnival. The Portobello Green scheme achieved a Civic Trust Award in 1983.

Buildings at the western end of the development include the Westway Sports Facilities (Fig 7.5) comprising a structural steel frame with profiled metal and brick cladding on a reinforced concrete raft, Bramley Road shops consisting of a composite concrete hollow clay pot roof on loadbearing walls on a raft, and Maxilla Print Workshops comprising lightweight roofing units on blockwork walls on a raft foundation.

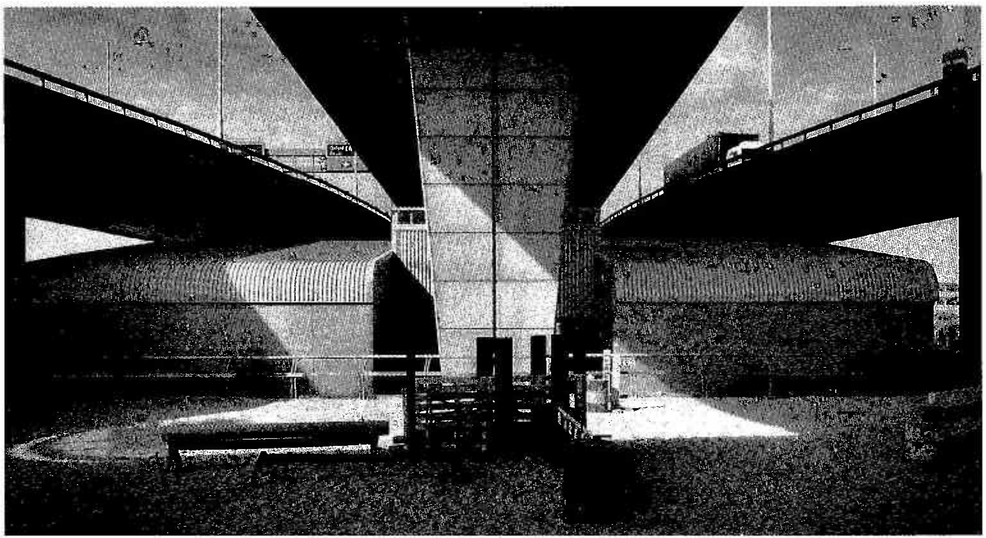


Fig 7.3 Tatters Yard Maintenance Workshops

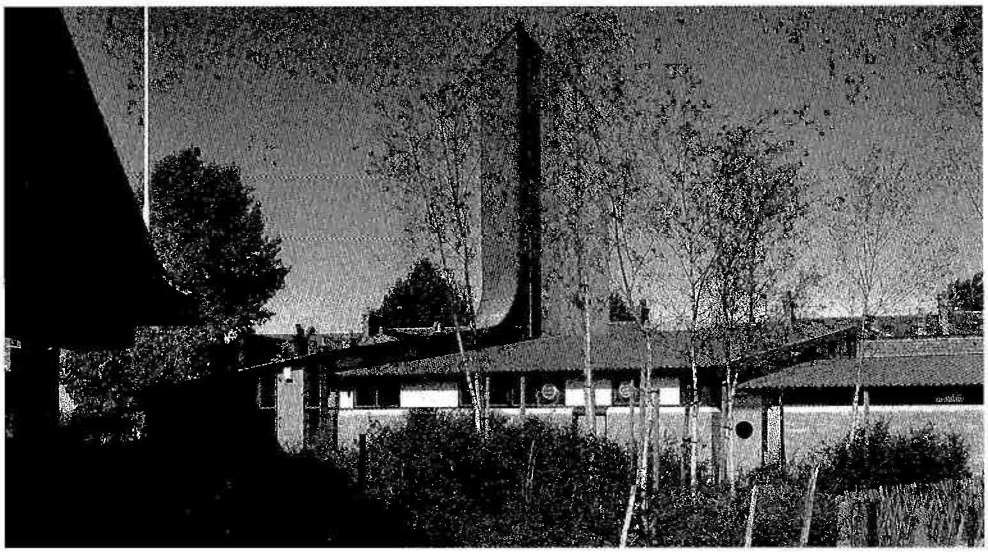


Fig 7.5 Westway Sports Facilities

All of these projects, while being small in scale, have been the result of lengthy consultations with local community groups. These groups have had to struggle to raise the necessary finance and subsequently building costs have had to be held tightly within a budget. However, all projects have proved to be very successful and popular and are an excellent example of inner city regeneration.

Peter Cunningham


Fig 7.4 Portobello Market Canopy

Head Office

Buro Happold
Camden Mill
Lower Bristol Road
Bath
BA2 3DQ
ENGLAND

Telephone: 0225-337510 (10 lines)
Telex: 449798 Burhap G
Fax: 0225-311779

Affiliated Offices

London

Buro Happold
23/27 Heddon Street
London
W1R 7LG
ENGLAND

Telephone: 01-439-7314

Kuwait

Buro Happold
PO Box 36666
Ras Salmiyah
KUWAIT

Telephone: 010-965-2410288

New York

Buro Happold
157 Chambers Street
New York City
NY 10007
USA

Telephone: 010-1-212-732-4691

Riyadh

Buro Happold
Riyadh
SAUDI ARABIA

Telephone: 010-9661-4784244

Hong Kong

Buro Happold
12/F, Shiu Lam Building
23 Luard Road
Wanchai
HONG KONG

Telephone: 010-8525-295508