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ARUP

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Front cover: Atrium roof, Whiteleys of Bayswater (Photo: Barry Shapcott)
Back cover: New River Wye bridge for Chepstow Inner Relief Road (Photo: Harry Sowden)

WHITELEYS OF BAYSWATER

Architect: Building Design Partnership

Ken Hatter

Introduction
The original Whiteleys building was constructed at the beginning of this century in London's fashionable Bayswater. It became famous as the world's largest department store, but after the war went into decline, together with the surrounding area. In line with current trends it has now been refurbished and partially rebuilt to form a new shopping complex. The rejuvenation of this building has had a considerable effect upon the locality, which is benefiting from an influx of investment and once more coming into vogue.

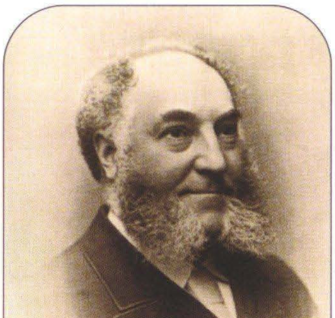
Historical background
In 1851 a young Yorkshire man of 20 visited the Great Exhibition in Hyde Park and was inspired to create the world's most lavish department store.

That man was William Whiteley.

Four years later he returned to London with just £10 in his pocket, determined to learn all he could about retailing. By 1875, he had acquired 18 shops in Westbourne Grove.

Operating under a slogan that simply read 'The Universal Provider', this remarkable man claimed that he could provide anything from a pin to an elephant — a claim that was put to the test by a doubting clergyman who at 4 p.m. on the same day of his order was the recipient of a large elephant at his stables.

By 1900 Whiteley had a staff of 6000 working at his stores and factories, and had acquired a rather contradictory reputation as both tyrant and benefactor; on the one hand he was not averse to sacking an employee for the smallest misdemeanour, but on the other, he left over £1m in his will to provide homes for the destitute aged.

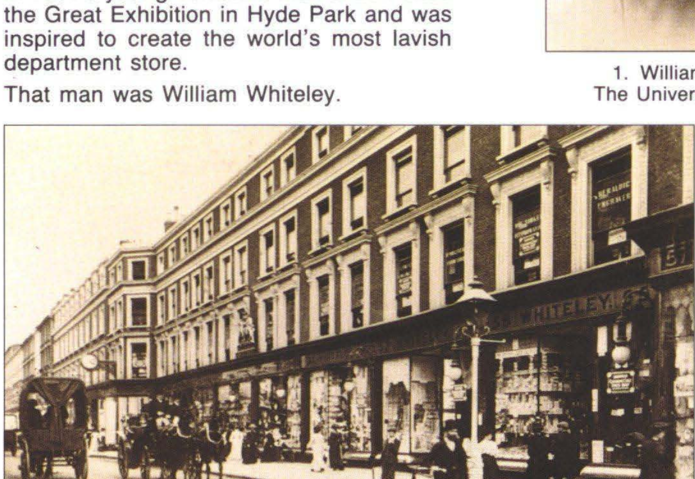


1. William Whiteley
The Universal Provider.

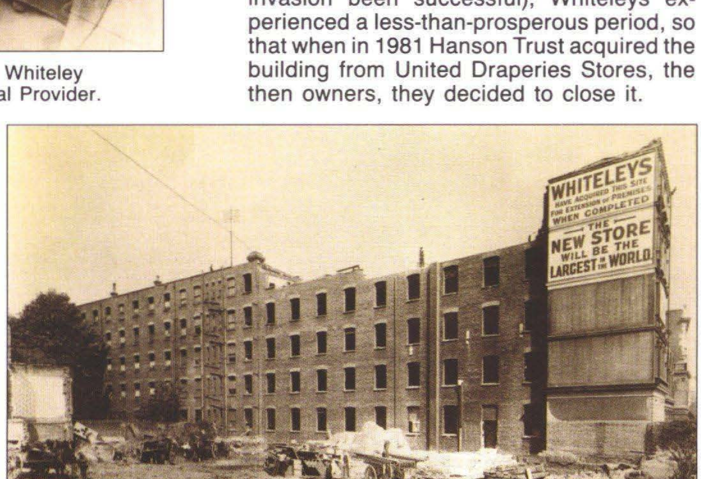
Alongside the daily running of his business which, among other things, included providing 5000 horses for cavalry manoeuvres, decorating Buckingham Palace, and providing two miles of seating for the opening of a tunnel under the River Thames, Whiteley commissioned the building of the world's largest department store. Designed by the architect John Belcher (1841-1913), this spectacular construction was opened by the Lord Mayor of London in 1912.

Unfortunately William Whiteley was never to see the completion of his store, as on 24 January 1907 he had been shot dead in his office by a man claiming to be his illegitimate son. Whiteley's creation continued to operate as a flourishing store, and in 1925 the facade to the older northern buildings was rebuilt by Curtis Green in the style of the Belcher building to complete the present imposing Queensway frontage.

After being owned by a succession of companies (and reputedly designated by Hitler to be his British headquarters had the German invasion been successful), Whiteleys experienced a less-than-prosperous period, so that when in 1981 Hanson Trust acquired the building from United Draperies Stores, the then owners, they decided to close it.



2. Whiteleys at the turn of the century.



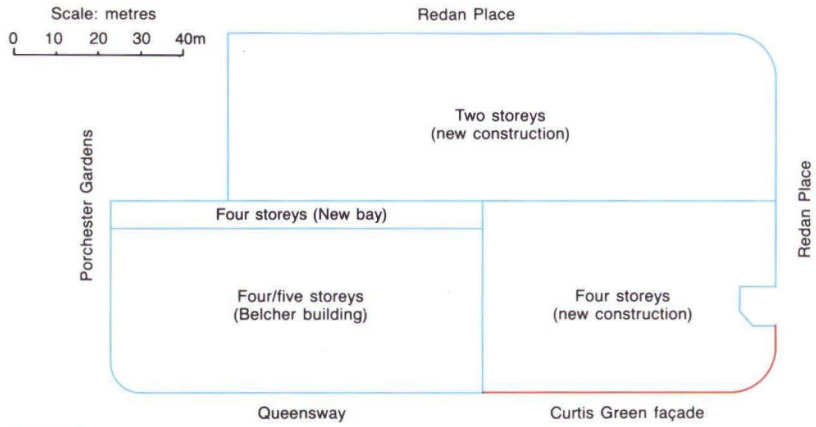
3. Construction of Belcher building (Photos: BDP archives)

The new complex

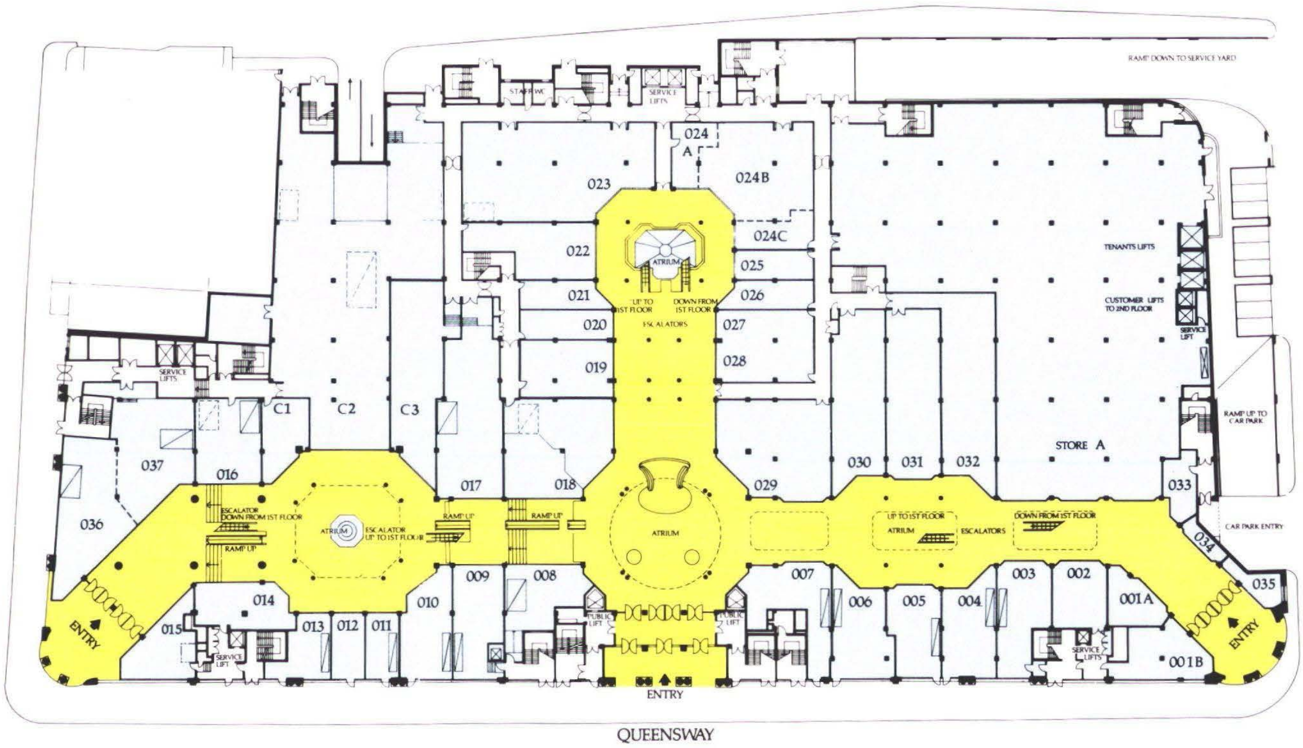
The Whiteleys Partnership was formed from a consortium of developers, including Arlington Property Services Ltd., London Metropolitan Estates Ltd., and Dartnorth Ltd., all operating under a chief executive, Jonathan Joseph of Bellhouse Joseph.

The Partnership purchased the site in 1986 and assembled a professional team, which included Building Design Partnership as architects and Ove Arup & Partners as structural and services engineers.

In order to obtain planning permission for the Grade 2 listed building, BDP had to come up with a proposal acceptable to English Heritage, which insisted on the retention of much of the Edwardian building and its detailing.

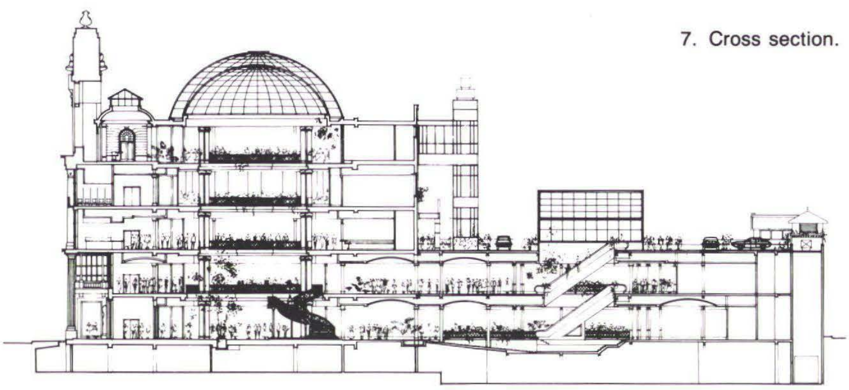


4. Key plan.



5. Ground floor plan.

6. Model interior. (Photo: BDP)



7. Cross section.

Planning permission was finally granted on 7 November 1986 with demolition beginning that same day.

Over £80 000 and six months were spent constructing a 1/50 scale model in four mobile sections which could be separated to reveal the intricately detailed interior. More than 4000 needle lights were incorporated, allowing life-like photographs to be taken for marketing purposes as shown above.

Comprising over 100 shops and many leisure facilities, the new centre has three main entrances on the ground floor. Passing along grand malls, the public gain access to 37 varied retail units, and a Marks & Spencer food hall. These grand malls interact with four dramatic atrium spaces, two of which have water features. Three of these atria rise through the full four-storey height of the front half of the building, with the middle of the three extended into the fifth storey which crowns the front central section. Lifts and escalators provide links to the upper levels.

The elegant 'La Scala' staircase in the centre leads to the first floor, where a Reject Shop and two more large stores plus 34 further retail units are situated. As with the ground floor, spacious malls provide access. There are also escalators leading to the customer car park on the roof of the two-storey rear section of the building. The fourth atrium is also situated in this rear section.

The second floor is also occupied by the food boulevard, with a choice of 18 restaurants, cafes and food bars. Also on this floor is the entrance to an eight-screen cinema and level access to the customer car park.

It had been intended that the third floor would be for retail-related activities, similar to the lower floors, while the fourth would house a spectacular rooftop restaurant. Plans are currently being reconsidered, however, and it is likely that both will be converted to luxury office accommodation.

Servicing is provided at basement level where there is ample provision for vehicular deliveries, goods handling and distribution, with goods lifts extending to all floors. Many tenants on the ground floor have extra sales or storage accommodation within the basement; there is also staff parking space.

△ 8. The restored facade. ▽ 9. The central atrium. (Photos: Barry Shapcott)

The construction works

The general public now using these facilities are unlikely to be aware of the scale and complexity of the works undertaken in the completion of this project, which occupies a site area of 180m × 90m.

The demolition had to be carefully planned in order to retain the original Belcher building, as well as the later Curtis Green facade.

It was necessary to provide temporary stabilization of this facade with lattice steel towers and gantries anchored to piled foundations. The demolition works inside the facade included the spectacular felling of an old brick chimney stack and the removal of large quantities of rubble.

Bulk excavation quickly followed the demolition works. New reinforced concrete raft foundations incorporated a waterproof membrane, together with underground drainage and cable ducts.

New concrete retaining walls and columns followed immediately, allowing new suspended floor slabs to be constructed, utilizing polystyrene void formers. These new construction works had to be stitched into the existing Belcher building and Curtis Green facade.

While they were taking shape, the alteration and restoration of the Belcher building was carried out. This included cleaning and repairing the facade, and the domes over its two atria.

The stability of the existing 1912 steel structure required upgrading by welding the joints of the framework, and considerable structural alteration was necessary to form new openings for escalators and service cores.

These early construction works utilized the whole site area. It was therefore necessary to provide temporary site office accommodation stacked on gantries around the building perimeter, beneath which there were facilities for the delivery and off-loading of materials.

Structural considerations

Philip Jordan

The structural works fall into two distinct categories: the refurbishment of the Belcher building and the so-called 'new-build' areas. The Belcher building provides approximately ⅓ of the total floor area. Its structure consisting of a steel frame supporting hollow-pot concrete floors, with foundations of steel grillages encased in mass concrete.

The new-build areas are in situ reinforced concrete on a column grid of 7.5 × 8m. The front zone matches the height of the Belcher building with the rear zones being two storeys high over a single storey basement.

Originally, a construction programme of just over two years was demanded from start of demolition to practical completion, with a mere five months' lead-in time for design.

The client therefore decided to negotiate the contract with Balfour Beatty Building Ltd. In order to obtain a flying start the works were broken down into an early enabling works contract, to include demolition, and the main construction.

The crucial decisions had to be identified and resolved early and fast, months before planning approval was received. The early dialogue between the design team, client and contractor therefore focussed on buildability issues. Avoidance of major temporary works to existing basement walls and vaults was achieved by not lowering the basement under the Belcher building and by locating the deeper basement levels for storage, car parking and service yard 6m or more inside the existing basement walls.

A new close-bored pile wall was installed along the rear boundary to the new basement which was relatively clear of the existing one. However, because of its proximity to terraced housing with shallow footings, and because of the depth of the new basement, the temporary works wall was regularly monitored until the new retaining wall and ground floor slab had been constructed.

An early study comparing the cost and speed of construction of new piled foundations against a raft favoured the latter solution on both counts. The raft thickness was 900mm supporting the basement and two-storey construction at the rear part of the new-build area.

This thickness was increased to 1200mm below the basement and four-storey structure constructed behind the 1925 facade, increasing in some areas to 1500mm where high column loads generated by service yard spacing requirements dictated.

A comparison was also made between alternative solutions for the new-build structural frame. A reinforced concrete solution was clearly identified as preferred by the team on grounds of cost and speed of construction (in terms of following trades). By using a one-way troughed slab spanning between solid strips, maximum headroom was also provided for landlord's and tenants' services. This provided a distinct advantage in service corridor areas.

Together with the early design and buildability studies for the new-build substructure and frame, a progressive series of investigations was undertaken within the Belcher building.

A comprehensive article appeared in *The Builder* of 14 June 1912 describing the design and construction of the Belcher building, both of which had noteworthy features. The structure consists of one of the earliest examples of steel-framed construction based on the 1909 LCC Regulations. These allowed, for the first time in the UK, the frame to be designed to carry all the loads on the building. The design of this was carried out by a Mr Alexander Drew, a mechanical engineer!

The article also proves that fast-track construction has still barely caught up with pre-World War I achievements. It claims that five acres of hollow pot concrete floor slabs were poured in a period of less than six months. The whole building was erected within 13 months of laying the foundation stone, including in situ carving of some of the decorative stone features.

With the contractor maintaining a small team on site from April 1986, initial investigations were concentrated on proving the accuracy of the details given in the article in *The Builder* (the only source of drawn information available), testing materials and opening up trial pits in the basement in conjunction with a site investigation.

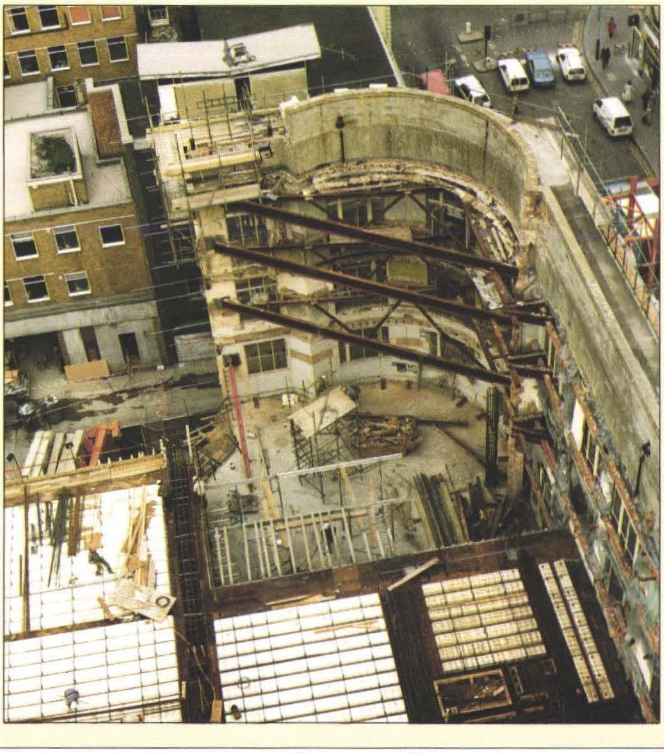
Further investigations became necessary to gain an understanding of the capacity of the floor slabs and steel frame in areas of the building subject to major modification. The change from a single department store to many individual units, public areas and associated facilities with full supporting services, involved the insertion of new lifts and escalators, staircases, services risers and roof-top plantrooms.

The existing timber floors were removed and lightweight floor build-ups developed to provide a stable bed for new high-quality tiled finishes. All the above modifications were incorporated without providing additionals columns or any strengthening works to the existing foundations, which were founded in London clay with bearing pressures up to 270kN/m^2. This was only possible through the removal of the frequent 340mm thick solid brick fire compartment walls provided within the existing store. New compartment walls were built using lightweight aerated blocks, generally 190mm thick.

At the interface of the Belcher building and new-build frame the depth of the new basement required the underpinning of 12 bases, up to 5m square. The major nature of this work led in turn to a proposal by the contractor to demolish the rear bay of the Belcher building at every floor level. Despite the additional work generated by this decision, which had to be approved by English Heritage, it led to a 'cleaner' structural solution for the rear Belcher frame. This was originally built as a hybrid of steel columns and load-bearing brickwork, which would have required extensive propping and stitching works to match the planning requirements of the new shops.

A common problem arising in early steel frameworks is that of identifying an adequate stability system for horizontal loads. Investigations indicated that while the original Belcher beam/column connections had some moment capacity it was well below that required by the current wind loading code. On the other hand the building had stood up satisfactorily for 75 years!

After much discussion it was decided to design for a horizontal load on the Belcher framework of wind load or 0.5% dead load, whichever was greater. A known stability system was introduced into the existing framework by means of welding up a large number of beam/column connections to form frames or sub-frames well-distributed throughout the plan area of the building.



Above: Rear bay of the Belcher building after demolition works.

Right: Rear stabilization of Curtis Green façade.

(Photos: Barry Shapcott)

Smoke control

Alan Bentley

The malls have a dedicated smoke ventilation system to allow the public safe means of escape in the event of a fire. Unusually for this type of system, the automatic controls are microprocessor-based and software-driven. Continuous and close collaboration with Arup R&D's Controls Group has been essential in order to develop the design into its final form to meet the stringent requirements of Westminster City Council's Building Control Department.

This ventilation system is made up of the following parts:

(1) Drop curtains around the void edges and between the zones on the ground and first floors, to form high-level smoke reservoirs

(2) Fire-protected ducts with connections to the smoke reservoirs incorporating addressable, normally open, smoke dampers

(3) Reversible axial flow fans to extract smoke or supply make-up air

(4) A controls system that operates automatically but incorporates manual over-ride for Fire Brigade use.

The fire detection/alarm system provides the data to the automatic controls and enable the ventilation system to operate effectively.

A mechanical smoke ventilation system was used, following the requirement that the malls be treated as a covered shopping centre development. The rejected alternative was to design the escape layout to the standards used in a department store, for which only a nominal smoke extract system would be needed.

In order to keep the number of extract fans, ducts and shafts to a minimum, and given the constraint that smoke reservoirs have to conform to certain parameters, it was necessary to zone the malls with a vertical pattern of sub-zones; the smoke reservoirs are consistent with each sub-zone. Each vertical zone has four riser shafts, each vertical shaft having a horizontal duct at every level to the associated smoke reservoir. The schematic arrangement of the malls (Fig. A) illustrates the zoning, sub-zoning and smoke reservoir principle.

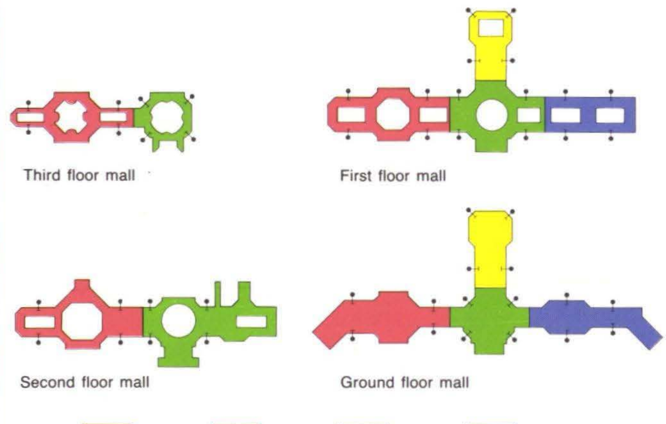
In accordance with the accepted principles in the Fire Research Station's smoke control design guide for shopping centres, the smoke from a fire within a retail unit is vented into the mall. The mall fire detection system will initiate the dropping of all smoke curtains within the centre except in either the ground or first floor where, for smoke extract purposes only, particular inter-zone curtains will be inhibited from dropping. This will create a double-sized sub-zone with eight regularly spaced points of extract. The sequence of pairing neighbouring zones is pre-determined in accordance with the table below:

Alarmed Zone (Ground/1st)	Coupled with . . .
1	4
2	4
3	4
4	2

The smoke dampers above and below the alarmed (double) sub-zone close and the fans switch to extract. The concept diagram (Fig. B) illustrates this arrangement.

Fans serving the adjacent zones operate in reverse to provide the necessary make-up air.

As well as coping with the different permutations of fan and damper operations, the controls system also has to ensure that they are sequenced in the correct order, starting with the alarmed zone. Also, should the standby generator be providing the motive power, it is essential that fans do not start simultaneously and overload the generator.



A.
Schematic arrangement of common riser shafts.

The controls diagram (Fig. C) illustrates how the various parts of the system communicate with each other via the two separate data loops. Electronic interface units enable the controllers and central processing unit (CPU) to transmit and receive data from the fire alarm system, dampers, fans and the fire brigade panel.

The inherent security of the system is provided by the following features:

- two separate data loops
- a 'hot' standby controller
- duplicate connections to the fire detection system
- duplicate interface units within the fire brigade panel.

Because the data loops have bi-directional data transfer a single break will not interrupt communication.

The controllers contain the coded instructions that initiate fan and damper operation (applications software). The CPU only handles the day-to-day housekeeping functions and graphics operations.

However, the controllers' application software also resides within the CPU as a back up.

It is important to realise that the various micro-processor packages used are standard components within the specialist manufacturer's HVAC Building Management System (BMS).

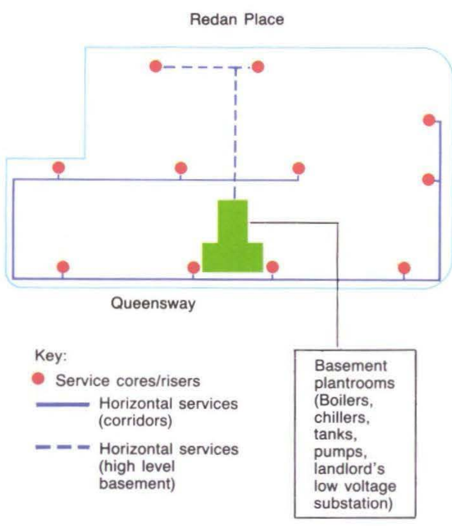
The decision to proceed with the micro-processor controls option was based on the following advantages over the more conventional option:

- from a generalised flow diagram it is relatively easy to implement software instructions
- the reduced number of electrical contacts increases overall system reliability
- the controls system is capable of monitoring itself for faults
- transmitted data can be checked for corruption
- loss of communication to individual interface units can be monitored
- changes to building usage can be readily accommodated without significant disruption.

As soon as the construction had progressed sufficiently, work commenced on the whole interior. The existing basement retaining walls were treated and rendered to prevent ingress of water and the existing pavement lights around the building perimeter were replaced to form smoke outlets. Internal walls were constructed and existing floors reformed or repaired as necessary.

The installation of the mechanical, electrical and public health services commenced in the basement, where distribution from the main plantrooms runs at high level along service corridors to the vertical service cores that connect to each level above. A complex building of this nature requires extensive pipes, cables and ducts which need to be carefully co-ordinated into very tight spaces, while providing access for commissioning and maintenance.

The basement plantrooms include heating and chilling equipment, considerable water storage and boosting equipment, as well as the electrical substations, three for the LEB and one belonging to the landlord. The large diameter drainage pipes are gathered and trapped before connecting to the sewers. There are five major outgoing connections to the sewers as well as water, gas and fire main incoming connections.

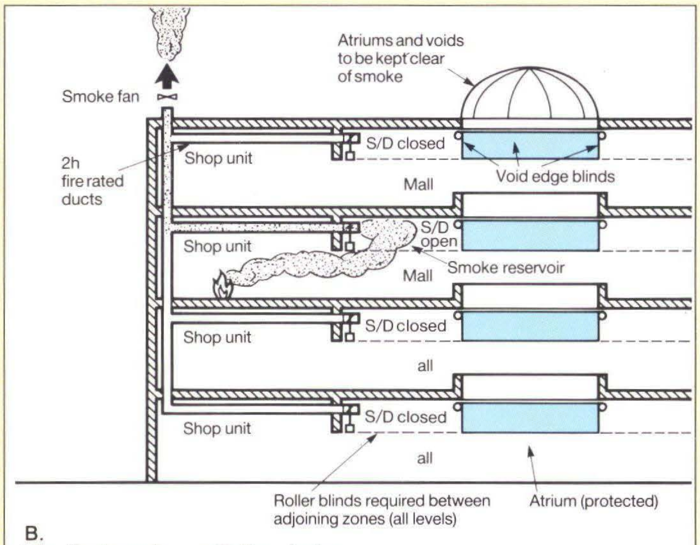


10.
Diagram of services distribution at basement (Note: Roof plantrooms are arranged above each service core).

The services at high level in the shopping malls are particularly congested in order to accommodate the landscaped ceilings within the headroom restrictions set by the existing Belcher building. Above the ceilings are many ducts, pipes, cables and automatic sprinklers, etc., all needed to provide a well-lit and temperature-controlled environment with the necessary safety and security provisions.

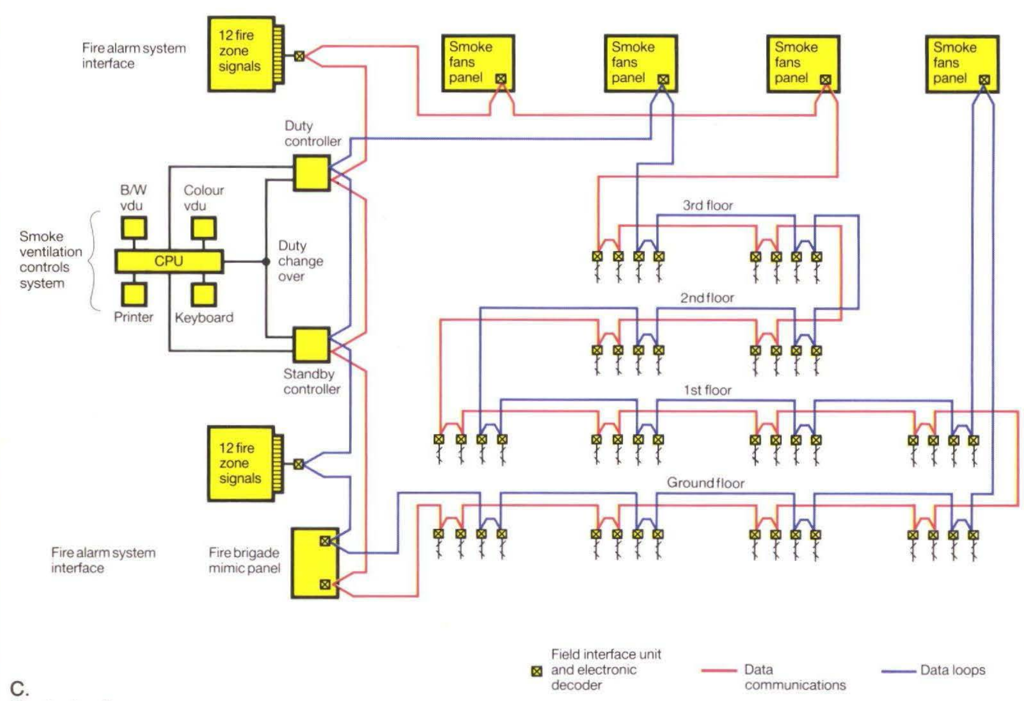
The smoke and fire control strategy for the building had to be very carefully considered in order to meet the regulations and achieve open atria and escalator voids connecting each level (see 'Smoke control', panel above).

The service corridors, as well as allowing delivery of goods to the rear of each shop unit, also permit the distribution of building services to the units. Each tenant was obliged to extend from the landlord's services and to fit out the unit in accordance with well-defined requirements and standards.



B.
The final smoke ventilation design.

Smoke curtain fully deployed on atrium floor. (Photo: Roger Olsen)



C.
Controls diagram.

Smoke control illustrations courtesy CIBSE Journal.

The decision to base the controls system around a BMS has since been fully justified on two counts:

(1) It became necessary, at the commissioning stage, to implement fan and damper re-sequencing together with the introduction of zone curtain control. This was undertaken and completed relatively quickly. With a conventional controls system this would have been impractical.

(2) There is at present a proposal to re-designate the third floor to office accommodation. The architect has stated a preference for incorporating the offices into the same fire compartment as the malls below. Following discussions with the Building Control Officer it is evident that the mall smoke ventilation system could be readily adapted to meet this requirement without too much disruption to the shopping centre operation.

Given the size and complexity of the development and that the controls application breaks new ground, the ventilation system still meets the basic requirements of being both reliable and economic. Further applications could build on our scheme and be enhanced with the following features:

- fibre optic data transmission (particularly appropriate in electrically noisy environments)
- distribution of the applications intelligence to each interface unit
- integration of the fire detection system into the same network
- development of expert systems for concept bench testing to ensure all failure scenario features can be analyzed.

It is evident that with present developments in micro-processor technology there will be an increasing number of similar applications.

11. Left: Part of the building management system in the chiller plantroom.

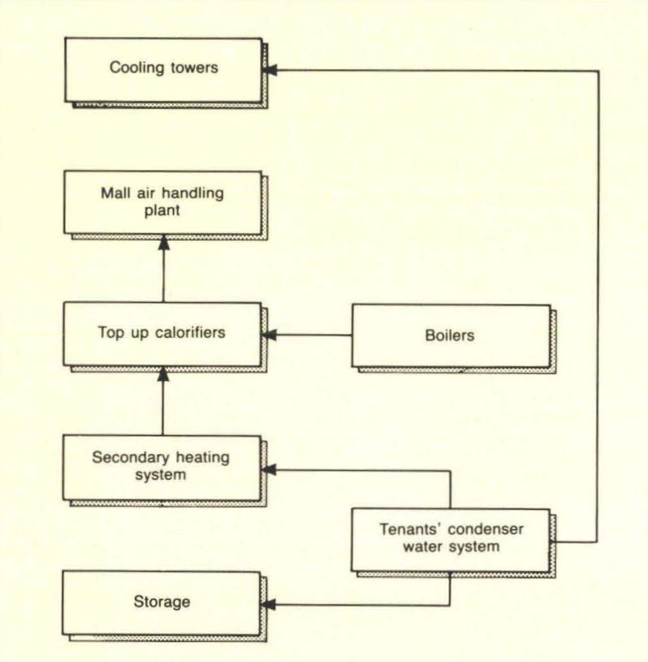
12. Above: Basement services corridor: pavement lights top right hand corner (Photos: Roger Olsen).

Heat reclaim

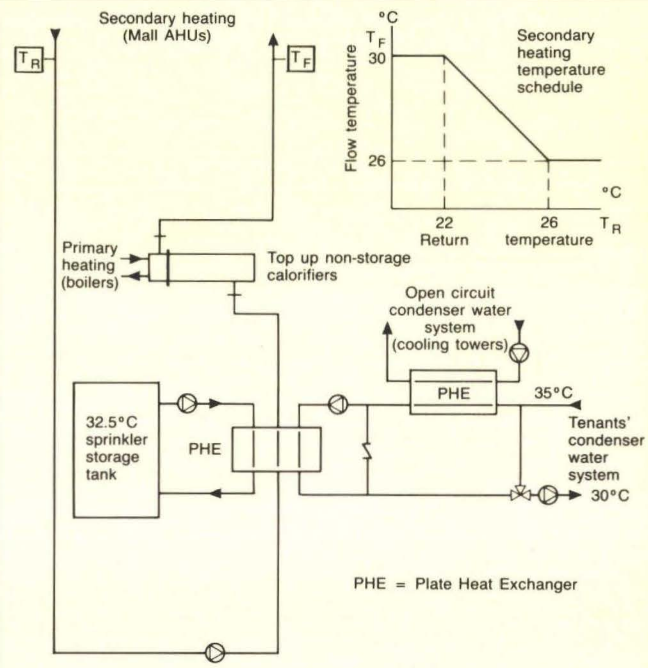
Alan Bentley

A dedicated, closed-circuit condenser water system is provided to enable tenants to dump the rejected heat from their individual air-conditioning systems. This waste heat is made available for re-use within the secondary heating system serving the mall air-handling plant. The sprinkler system storage tank is also incorporated into the heat re-claim system for thermal storage should the secondary heating system be temporarily satisfied.

The block diagram of the heat re-claim system shows the principle of operation. During the summer when there is no heating requirement the heat from the tenants' condenser water system is rejected to the cooling towers via the open circuit condenser water system. In order to improve the thermal capacity of the storage, the secondary heating flow temperature is varied against its return water temperature. Under part-load conditions the flow temperature will be less than design and a greater temperature difference will exist between the stored and flow water temperatures. This is illustrated below.



Block diagram of heat reclaim system.



Schematic arrangement of heat reclaim.

13. Car park at rear. (Photo: Peter Mackinven)

The roof plantrooms are organized above the main service cores and contain various air-handling plants and other equipment. The centralized cooling towers and stand-by generators for essential services are located at the rear of the Belcher building.

Considerable work was required both to the existing roof and to weatherproof the new structure. This had to be largely completed at an early stage to permit the finishes to proceed inside the building beneath. In the Belcher building the existing asphalt roof finish was repaired as a temporary measure, additional gullies and improved falls being provided in conjunction with a new asphalt membrane.

The finishes work was particularly concentrated in the shopping malls and included laying new high quality marble floors with medallion patterns at main intersections and the restoration and reprovision of ornate balustrades around escalators and other openings. All the finishes had to be integrated with the services activities, preceding erection of the ceilings. The existing plasterwork to the columns around the atria had to be refurbished and repaired. Moulds were made to recreate the original decorative rams' heads at the top of the columns. The ornate ceilings were prefabricated in large fibrous plaster units, assembled on site and joined together with in situ plasterwork. The existing 'La Scala' staircase required careful refurbishment to restore it to its original splendour. (While on a visit to Milan we made a special detour to La Scala hoping to find the original upon which we assumed this was based, only to discover that there is no such staircase. The curator at the opera house thought it must be a figment of William Whiteley's imagination.)

The work on the new atria included lightweight steel structures to support double glazed units. A prefabricated steel gantry extends along the rear of the building to provide secondary fire escape from the third floor; this connects to steel stairways and provides a further facility for the distribution of services.

The testing and commissioning of the various building services was a particularly critical operation occurring towards the end of the building contract. It had to be carried out in sequence, taking account of the programming for completing various zones. Certain operations required dust-free conditions at a time when the final finishing works were still in progress.

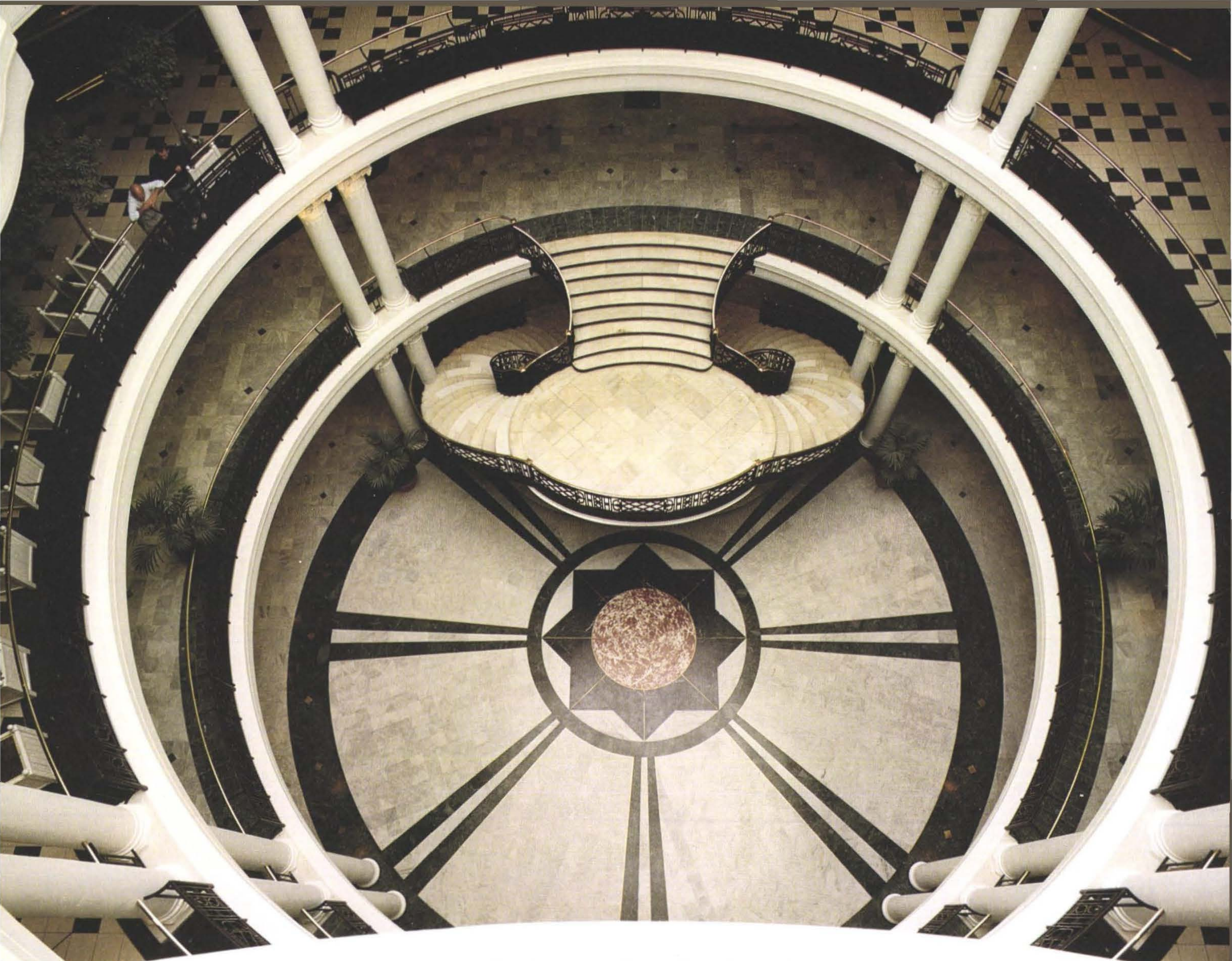
During the closing stages of construction the various tenants were busy doing their fitting-out works, requiring access and other facilities that needed to be carefully considered in relation to the main contract works.

Some tenants required alterations to the latter which had serious implications, particularly on the commissioning and testing of services. Each tenant had to be monitored to ensure compliance with the predetermined requirements and this had to be verified before the tenancy services were connected to the landlord's systems.

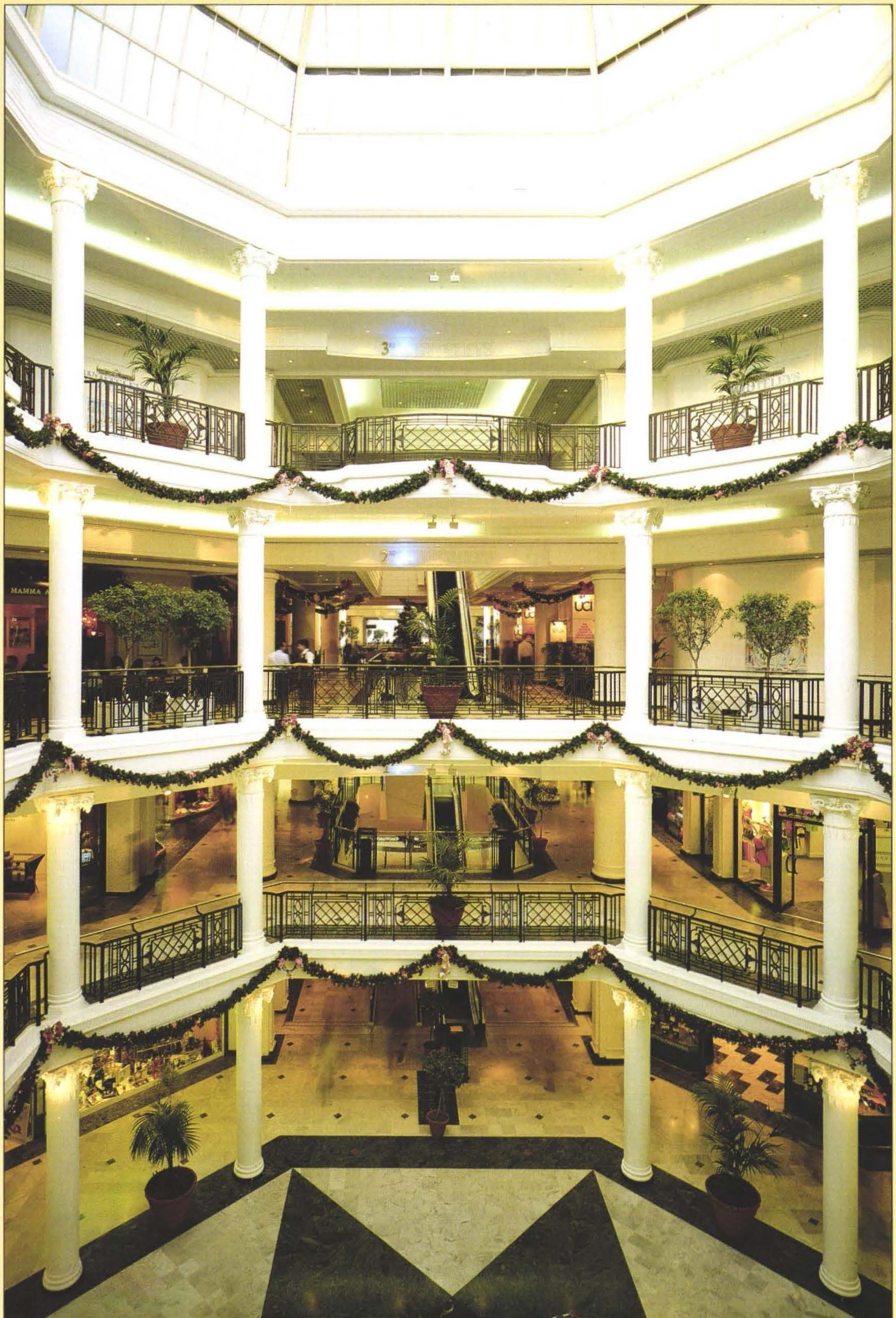
Conclusion

The planning and height restrictions imposed by retaining the existing building, combined with the complexity of detailing, resulted in the need for the careful integration of services within very restricted spaces.

Flexibility was needed to cater for varying tenants' requirements. The monitoring of tenants' fitting-out works against necessary predetermined procedures became an onerous and critical factor. Practical completion was achieved on 16 June 1989. The centre officially opened on 26 July 1989.



The 'La Scala' staircase. (Photos: Barry Shapcott)



Whiteleys of Bayswater: West atrium. (Photo: Peter Mackinven)

Credits

Client:
The Whiteleys Partnership

Architect:
Building Design Partnership

Structural & services engineers:
Ove Arup & Partners

Quantity surveyor:
Monk Dunstone Associates

Main contractor:
Balfour Beatty Building Ltd.

M&E contractor:
Balfour Kilpatrick Ltd.

The authors gratefully acknowledge the contribution of the Whiteleys design team in the preparation of this paper.

The management of the Zimbabwe CSC capital development programme

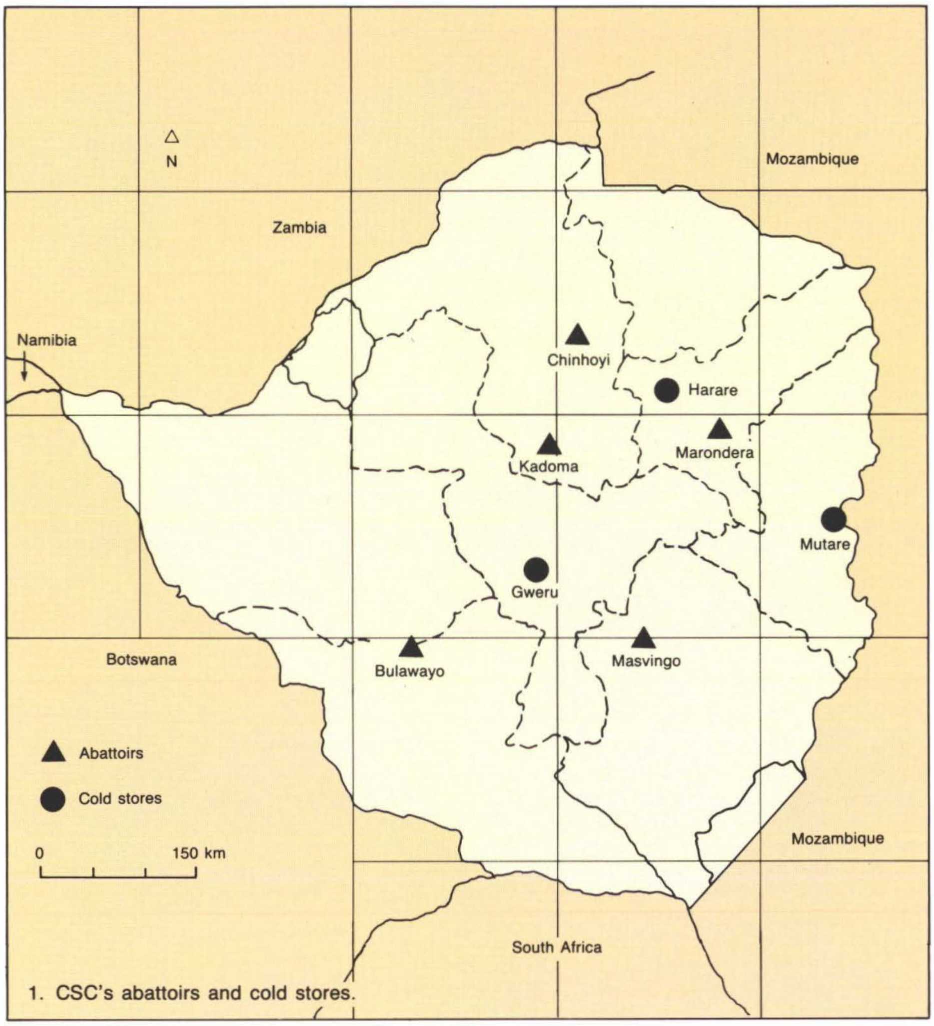
Simon Murray

Introduction

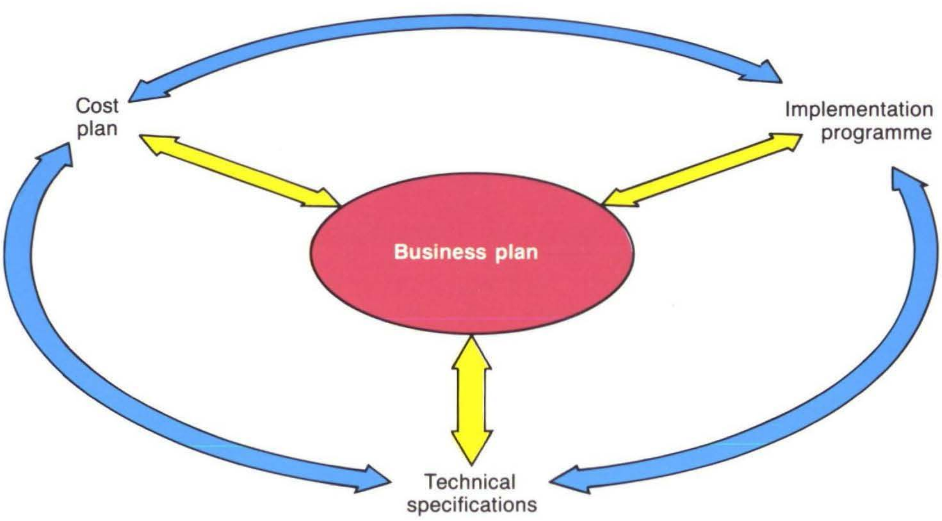
Zimbabwe is one of Africa's leading cattle producers. Its Cold Storage Commission (CSC) was established more than 50 years ago to provide the country's cattle farmers with the production, storage and distribution facilities that they needed to sell their beef.

Today it is a major parastatal organization which slaughters some 400 000 head of cattle a year, supplies the local market, and exports some 12 000 tonnes of frozen and chilled boneless products to regional and European markets.

Our work with CSC began in June 1983 when Arup Economic Consultants were appointed to undertake an extensive study of Zimbabwe's livestock sector and of CSC's role within it. The feasibility study, which was supported by the British Government under the Aid and Trade Provision, proposed a programme of investment of nearly £85M in new facilities to equip CSC for the next 20 years. CSC accepted the report and decided to proceed with a capital development programme, embracing seven separate projects. Four are relatively small improvements to CSC's existing plants undertaken with their own resources. The three major projects are the Harare Multi-purpose Complex, the Bulawayo New Abattoir and the Masvingo Refurbished Abattoir. The capital development programme is presently under construction with the facilities at Harare and Bulawayo scheduled to be commissioned by the middle of 1990. The management of the programme, the subject of this paper, is being undertaken by CSC, with the help of Ove Arup & Partners.



1. CSC's abattoirs and cold stores.



2. Business plan as the basis for project control.

THE FEASIBILITY STUDY

This was carried out in Zimbabwe by a team of agricultural economists, meat-processing specialists, and engineers. It assessed the current structure and condition of the industry from the cattle farmer to the butcher and forecast development through to the year 2004. From this emerged the specification of the facilities that CSC would need over the next 20 years, together with proposals for financing the investment. The forecasts from which the proposals were derived were the basis of sensitivity tests which established the robustness of the investment.

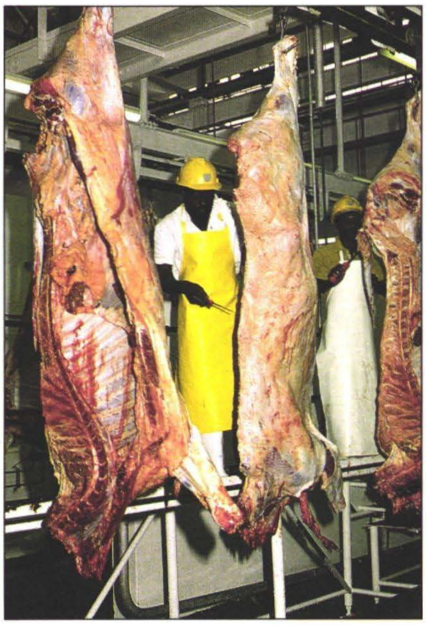
The feasibility study was a fascinating exercise which deserves a paper in its own right. It set out a basic business plan for investment in the capital development programme, and defined the parameters for its success.

This business plan became a reference point for the team when deciding the scope of individual projects, their target budgets, and implementation schedules. Two particular issues were central to the study and have continued to influence the programme.

Although beef exports are the key justification for the capital development programme, the three new plants are designed to serve the domestic market, the chilled prime cuts for the European Community being produced at CSC's existing abattoirs in Marondera and Chinhoyi. In calculating the production and storage capacities for the new plants, the study team had to assess growths both in the supply of cattle to the abattoirs, and of domestic demand for beef, and the types of products that Zimbabweans would want to buy. Unfortunately these trends are very sensitive to climatic cycles, government pricing policy, and average incomes.

In the two years between the completion of the study and the preparation of the final specifications for the three plants, CSC's operating environment had already begun to change, and plant capacities were adjusted accordingly. Throughout design and procurement it has been necessary to modify layouts and specifications to ensure that the new plants are right for CSC when they open, while still managing these changes without loss of control or undue disruption to the project teams.

As well as deciding what facilities were needed, the feasibility study estimated the costs of the three projects and put forward proposals for financing their construction. It recognized the importance of minimizing the foreign exchange (forex) costs of the projects, which would have to be financed by supplier credits or loans from international development agencies. Although these loans would be at attractive interest rates, the repayments on them would be in foreign currencies and the signs were that the value of the Zimbabwean dollar would drop against the major European currencies over the life of the investment.



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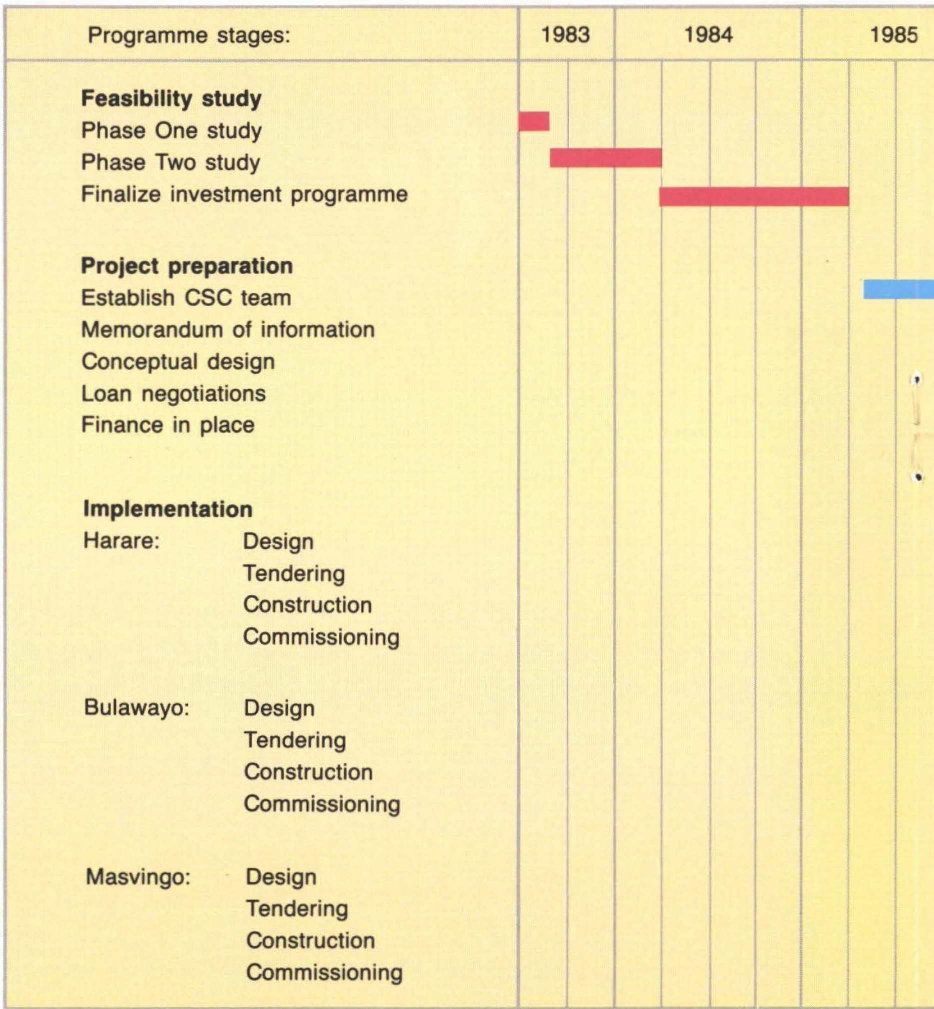
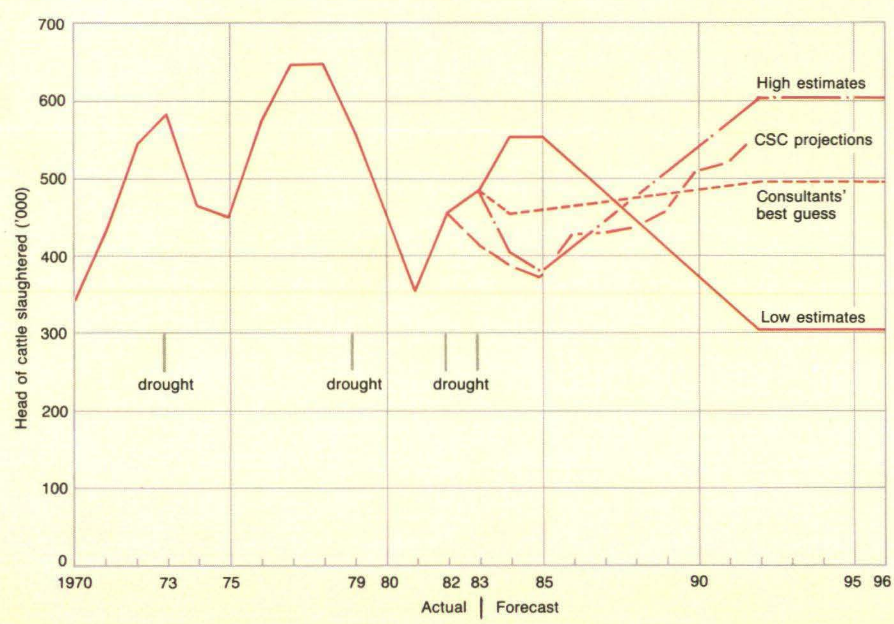


4. Capital development programme: Implementation schedule.

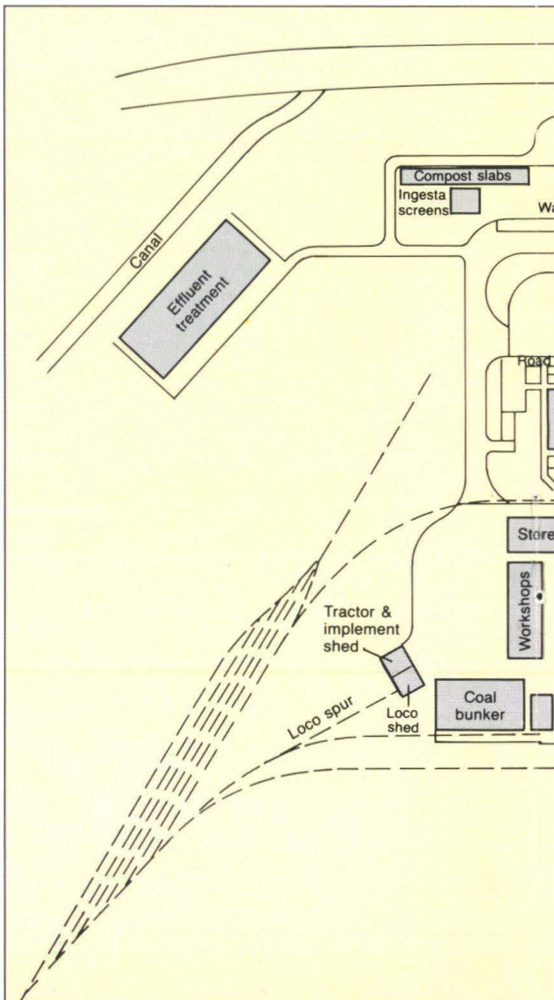
It is always difficult to make direct comparisons between initial estimates and final costs, as one must allow for inflation and for costs related to changes in specification. The comparison in Table 1 does show, however, what can be achieved when the objectives expressed in the feasibility study are carried through into design. By the time that the concept design had been completed and approved budgets established, the forex costs had been reduced by half with almost no increase in the local costs. Over the same period the value of the Zimbabwe dollar in European Currency Units (Ecu) weakened from Ecu 0.92 to Ecu 0.69. At the time of writing the rate is about Z$ 1.00 = Ecu 0.45.

Table 1: Development of project cost estimates * base date † including escalation

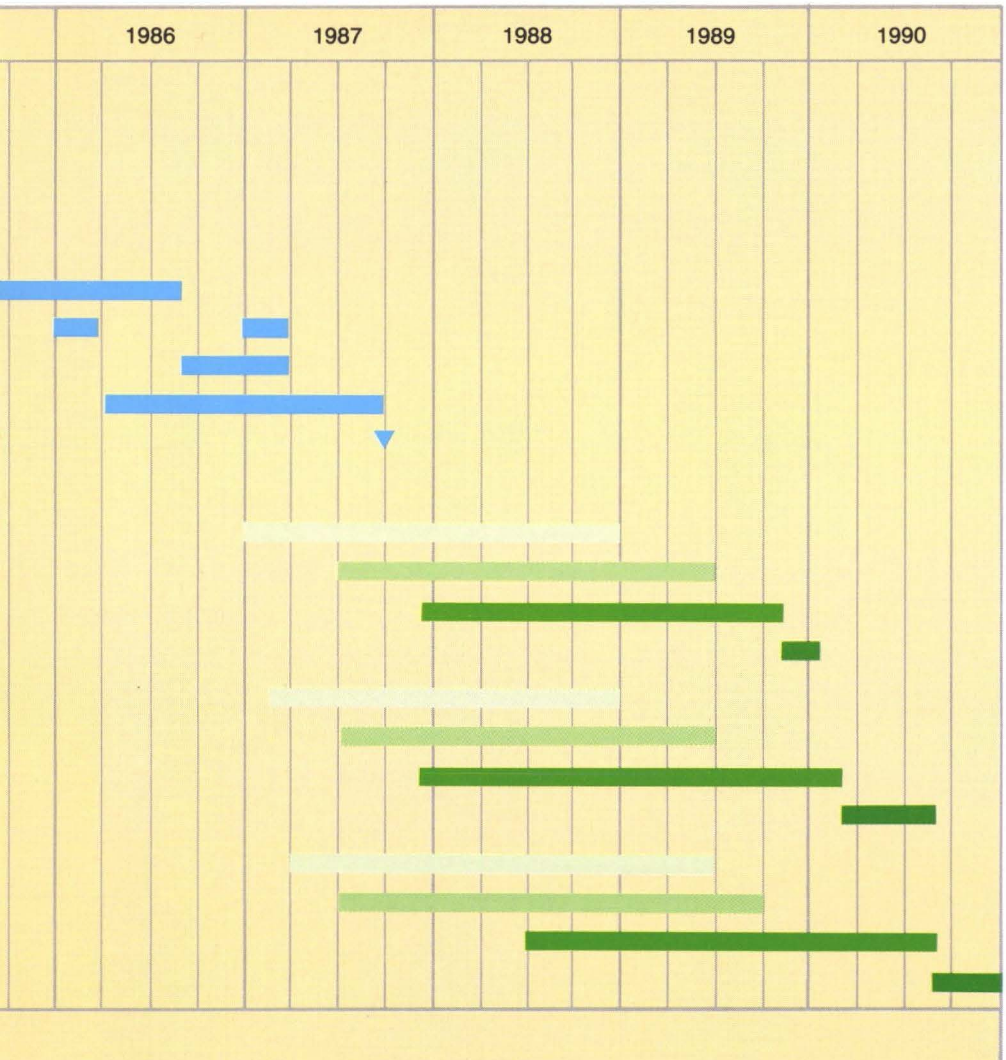
	Feasibility study		*Approved project budgets*			
	1 January 1985*		1 January 1986*		Forecast final cost†	
	Local Z$(M)	Forex Ecu(M)	Local Z$(M)	Forex Ecu(M)	Local Z$(M)	Forex Ecu(M)
Harare	22.9	9.9	22.1	5.9	35.7	6.7
Bulawayo	25.7	21.8	31.6	10.9	56.1	12.1
Masvingo	14.4	11.2	18.3	7.0	40.5	8.0
Total	63.0	42.9	72.0	23.8	132.3	26.8

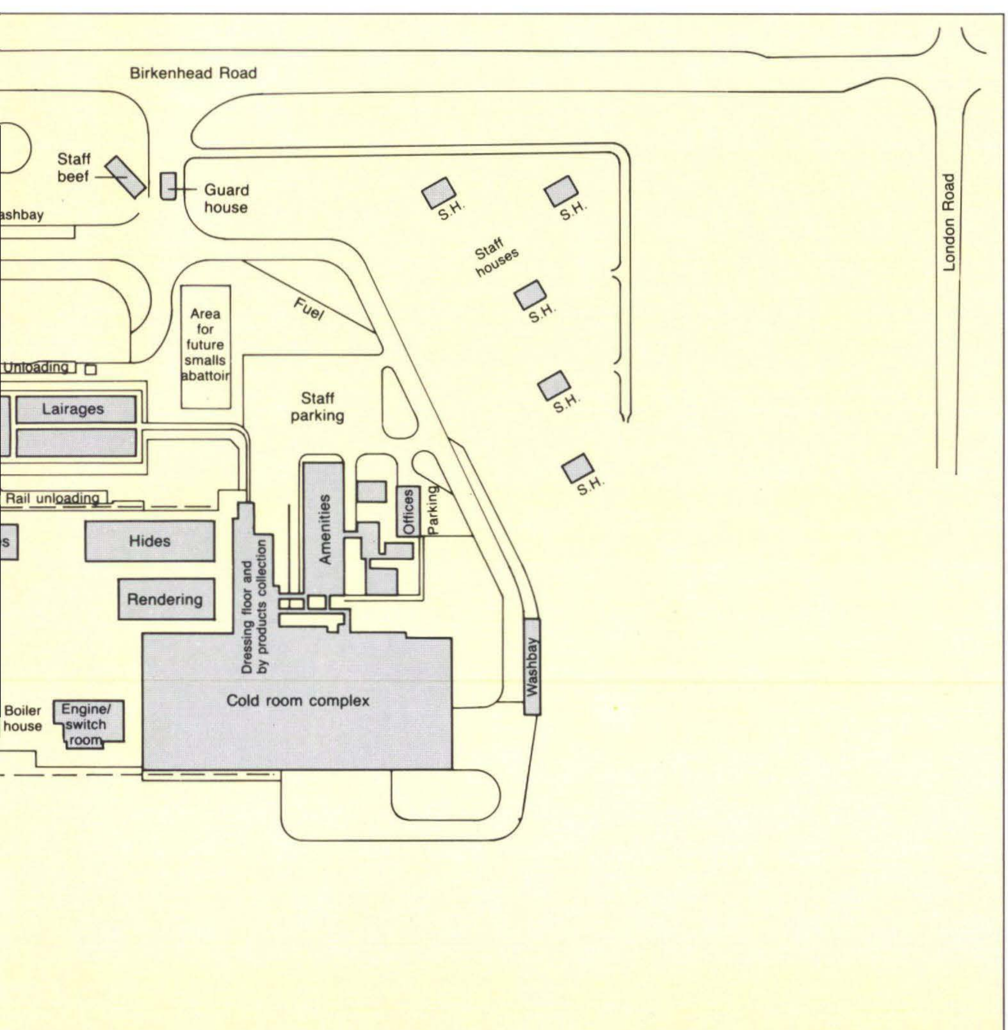


5. Feasibility study: Livestock supply forecast in 1983.



6. Bulawayo new abattoir.





CAPITAL DEVELOPMENT PROGRAMME

Objectives

Soon after the completion of the feasibility study it was established that CSC had two clear objectives in implementing their capital development programme. The first was to develop facilities appropriate to their needs at a reasonable cost and within a sensible timescale. The second was to maximize the involvement of Zimbabwean firms in the design and construction of the projects. By doing this CSC would minimize the foreign exchange costs and would also ensure that the plants could be maintained with local resources.

Extensive discussions were held with CSC to decide the best way of achieving these objectives. One approach, which was proposed by several European contractors, was to seek bi-lateral funding for a turnkey construction contract. It was rejected on the grounds that CSC would lose control of the design and, in spite of subsidized bi-lateral loans, it was unlikely to be the cheapest solution. In the end CSC elected to manage the design and procurement of the plants themselves and seek loans from the international development agencies for specific packages of work. They recognized that they would themselves have to take on the preparation of the projects to the point where financing could be secured and that they would need help from foreign consultants to do this.

The three major projects

The Harare Multipurpose Complex is a new cold storage and distribution centre, now being built on a greenfield site in an industrial area on the outskirts of the city, which will supply beef to Zimbabwe's largest conurbation. It will contain a new national vehicle workshop for CSC's fleet of refrigerated pantechnicons and space for the extension of the facility and for the construction of an abattoir if this is needed in the future.

Beef will be transported from the abattoirs to the new complex by road and rail, arriving in the form of chilled or frozen quarters and frozen cartons of offal. The cold rooms will have the capacity to store 1760 carcasses as well as 520 tonnes of packed frozen offal and *Trupac* economy beef, produced on the premises by cutting frozen quarters into small portions and then packaging them for sale in special outlets in the high density suburbs. Beef and other products will be distributed from the complex in CSC's own delivery trucks and the entire process will be overseen by a new computerized weighing, invoicing and stock control system.

The Bulawayo New Abattoir is being built beside CSC's existing abattoir which it will replace when it is opened. It is designed to slaughter 800 head of cattle a day, although initially the dressing floor itself will be equipped for a capacity of 600 head/day. Cattle will arrive by road and rail and be held temporarily in covered lairages. After they enter the stunning boxes at low level, their carcasses will be lifted by conveyor to the dressing floor one level above. In the rooms beneath the dressing floor, offal and other by-products will be processed and despatched. All of the facilities will be designed to EC veterinary standards.

The new abattoir will be provided with a 12 000m^2 cold room complex which, in addition to freezers and chillers, will house a boning room and *Trupac* production lines. A separate rendering plant will produce blood and bone meal from waste material.

The Masvingo Refurbished Abattoir, as the name suggests, is a major reconstruction of an existing facility. The existing boilerhouse, lairages, stunning and low-level bleeding areas will be retained, with a completely new dressing floor, rendering plant and cold room block added to give a capacity to slaughter 400 head of cattle and 200 small stock per day. The new facilities are being built while the existing abattoir continues to operate and the two parts will be brought together during a planned shutdown.

Project preparation

In March 1985 CSC chose the team that would work directly with them in preparing their capital development programme. Ove Arup & Partners International (OAPIL) were appointed as project management consultant to work alongside CSC's financial advisor, Standard Chartered Merchant Bank Ltd. (SCMB). Union International Consultants (UIC) were retained as process consultants to advise and support CSC's own process engineering team in Harare.

It was hoped that the team could be assembled in Harare within weeks. Unfortunately CSC did not have foreign currency to pay for the consultancies and some 18 months passed before Britain's Overseas Development Administration (ODA) agreed to finance them from their technical co-operation funds. During this time the consultants put together with CSC the documentation needed to secure ODA's support and to begin discussions with the international development agencies on project finance. At the same time CSC made formal submissions to the Government of Zimbabwe to get the capital development programme into the public sector investment plan and to give it national project status.

Preparation is the most important phase in a project's development, the stage at which the technical specification is finalized and the arrangements for procuring and financing are decided. It is the time, before any major commitments have been made, when the client and immediate advisors have freedom to consider a range of possible implementation strategies and choose one.

The preparation of the capital development programme started in earnest in September 1986 and was essentially complete by the middle of 1987 when the negotiations with the funding agencies were drawing to a conclusion. The exercise began with the establishment of the project team in Harare. CSC's team was already in place, although it was necessary to define how it would be structured and how it would interface with the rest of CSC; an important consideration when many different parts of the organization had to contribute to the projects. CSC had already begun negotiations with local consulting firms, which were concluded with the appointment of Ove Arup & Partners Zimbabwe as prime agent for the Harare project and Scott Wilson Kirkpatrick for the abattoirs in Bulawayo and Masvingo.

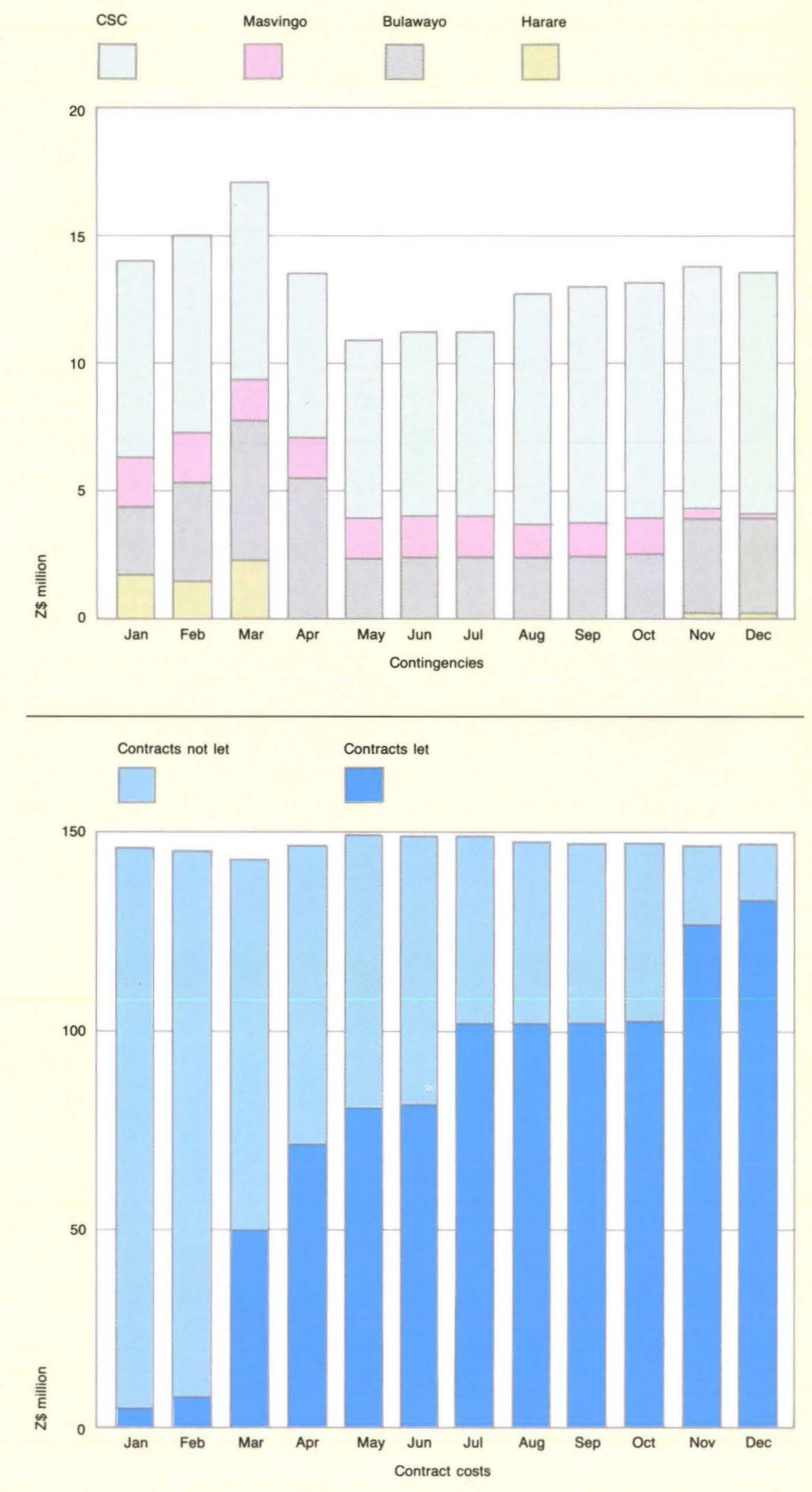
CSC's process engineering team set to work with the local consultants on the conceptual design of the three plants. At the same time the project management team began to develop the cost plan, the implementation and contract strategies, and proposals for the management of procurement and construction. These different aspects were interrelated and a balance had to be found between CSC's desire to control the procurement of the materials and equipment and the limited management resources that were available to do it. In the end it was decided that each project would be procured under some 30 separate contracts with the project consultants administering the contracts and providing overall co-ordination on site.

While the procurement strategy was coming together, initial discussions were held with the bi-lateral and international funding agencies. it soon became clear that the local costs would be financed by the Government of Zimbabwe while loans could be obtained from the Commonwealth Development Corporation and the European Investment Bank to cover the forex costs. Separate arrangements would be made with ODA to finance the secondment by the overseas consultants to CSC of key staff to strengthen their engineering and project management teams. Once the financing plan was agreed in principle the team prepared a Memorandum of Information as a formal summary of the project proposal. This was developed further with the funding agencies and became the basis on which the loan agreements were formulated.

It was realised early on that neither CSC nor their local consultants had word processors or the micro-computer systems that are commonly used in the management of major projects. Once again, ODA stepped into the breach and financed the purchase of seven Ferranti micro-computers with printers and software. With help from Arup Computing and a local computer firm, these were imported and installed in the offices in Harare. Basic project management systems were set up and staff from CSC and their consultants trained in their use. Without these computer systems it is unlikely that the team would have completed the volume of documentation that it undertook in the following two years.

The project team

At the core of the project team is CSC's own client group, based in their regional engi-



7. Control of commitment against contingencies: Local currency budget 1988.

neering office in Harare. The group is in three parts: the process engineering team, staffed jointly by CSC and UIC, is responsible for the design and procurement of all process and refrigeration equipment for the three new plants: the project management team provides the overall management and financial control of the capital development programme while the operations team ensures that the engineering staff in CSC's existing plants are properly supported.

The CSC group is the interface between CSC's senior management and the projects. It gives direction on all technical matters, controls budgets and expenditure, co-ordinates all contacts with Government departments and ensures that CSC's general manager is fully briefed at all times.

The detailed design and procurement of each project is undertaken by the project consultant and the team of sub-consultants.

The sub-consultancies, which include quantity surveying, architectural design and effluent treatment, are entirely domestic although they were arranged with CSC's knowledge and approval. The project consultants work closely with CSC's process engineering team who function as one of their designers as well as their technical client; a complex relationship which needs careful handling. Although the arrangement of having a single firm responsible for delivering each project is sometimes wasteful of resources, it clarifies responsibility.

The development of the contract strategy led to the project consultants' appointments being extended to include the co-ordination and management of construction on site.

This task is undertaken in each project by a site management team of between three and four engineers. With Zimbabwe's construction industry in the middle of a boom it has often been very difficult to recruit suitable staff. Although the approach has saved the Government of Zimbabwe several million dollars in foreign exchange, it has been difficult at times to obtain immigration approval to allow the consultants to recruit more site management staff overseas.

Design development

As an expert technical client CSC have been involved from the outset in every aspect of the design of the three projects. Details which might appear to the project consultants to be unimportant can be crucial to the hygienic operation of the plants and must be considered by several different departments within CSC. From the outset it was recognized that the approval of the consultants' designs would be a lengthy process.

The projects have been developed in three clearly defined stages: concept design, outline design and design development. At the end of each of the first two stages the consultants were required to submit a full design report, including cost estimates and implementation programmes, for CSC's approval. The report on the outline design became the basis for the implementation of the project as, thereafter, each contract package followed its own path through design development, tendering and construction.

In general it has been CSC's policy to complete the design of a particular package of work before letting a contract for its construction. In the case of process and refrigeration equipment, much of the detailed design work has been done by the contractors and steps have been taken to ensure that their programmes did not delay the design of other works. At the basic level this had involved defining areas within the structures for equipment and service ways. More detailed design co-ordination has been achieved through regular meetings between the international process contractors and the project consultants in Harare.

Cost and financial control

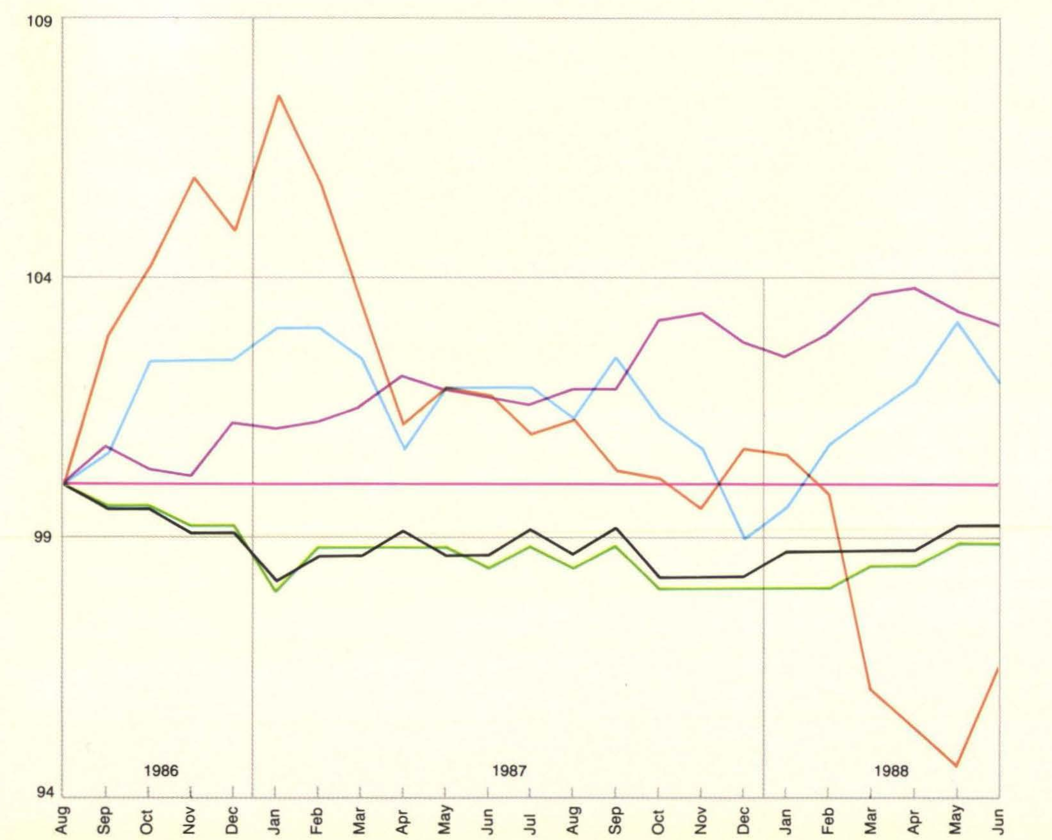
CSC are implementing the capital development programme within a fixed budget which was defined during the negotiation of the project loans. CSC's project management team have been aware from the start that the local currency and forex budgets cannot be exceeded and have instituted a strict regime to control commitments and expenditure against them.

Cost control began during conceptual design with the review of the project budget in the feasibility study and the preparation of detailed cost plans. At that stage it was already clear that forex costs would be financed separately from local costs and the decision was made to separate the two in the cost plans; local in Z$ and forex in Ecu. The Ecu was chosen for the planning and monitoring of forex costs as it was anticipated that most of the imported equipment would be sourced in Europe. Being derived from a basket of European currencies, the Ecu was likely to remain reasonably stable.

In the early stages of the development of the design, the project cost plans were broken down by engineering discipline and function so that the relative costs of different parts could be readily calculated. During outline design the contract strategy emerged and each project cost plan was broken down by contract package, grouped under disciplinary headings. A contingency allowance, to be used at the project consultant's discretion, was included as a separate element. When the report on the outline design was approved by CSC this cost plan became the Approved Project Budget.

Throughout design development, tendering and construction, the project consultants have been required to maintain their cost plan and a separate cost report showing their current forecast. The reports are submitted monthly in a standard format and are consolidated by the CSC team into a cost report for the entire capital development programme.

The control procedures that lie behind the cost plans and reports are designed to ensure that all commitments are fully evaluated before they are made. Minor adjustments are made by the project consultants and balanced against the project contingency. Any substantial change or significant contract variation is submitted to CSC for approval before being made. Where the change originates with CSC or is the result of an unforeseen circumstance, a formal change to the Approved Project Budget is authorized by CSC.



8.

8.
Major European currency exchange rates with Ecu.

Aug 1986 = 100

Within CSC's project management team, priority is given to controlling all commitments against the sum of the available contingencies and expenditure against sources of funds. Every three months the project consultants prepare detailed expenditure forecasts which are consolidated with those for CSC's own budgets. This is used to plan the drawdown of loan facilities into the accounts from which payments are made to suppliers and contractors.

The Government of Zimbabwe has quite complex procedures for allocating its own foreign exchange resources to the import of materials and equipment for the construction industry. The supply of many of the imported goods needed by local contractors is handled through these channels and the CSC team plays a central role in co-ordinating the contractors' applications to the relevant Government departments.

With more than 95% of the supply and construction work committed, the forecast cost of completing the capital development programme is still within the original budget.

Contract strategy

Each of the three projects has been divided into some 35 separate prime contracts for construction, about ⅔ being for civil, building and services works, and the balance for supply of equipment, ranging from forklift trucks to office furniture. This contract structure was devised to achieve CSC's objective of maximizing local content while retaining a project of manageable proportions.

With the exception of the contracts for the supply and installation of process and refrigeration equipment, all have been let to local firms through the Government of Zimbabwe's established tendering procedures.

Tenderers are required to give with their tenders an estimate of the forex that they will need in order to import essential equipment and construction materials. These funds are then provided from CSC's project resources or through the Government's own import procedures.

In the development of the contract strategy it was decided that the detailed design, supply and construction of each of the major process and refrigeration systems would be placed with one contractor to give clear responsibility for their final performance. The systems for the three projects were divided into eight contract packages and six international firms were prequalified to tender for them. In the event all eight contracts were awarded to Intercool Food Technology of Denmark, a subsidiary of the British firm of process engineers, APV plc. This arrangement not only gave CSC the cheapest solution, but also ensured that similar equipment would be used in all three projects, thus simplifying maintenance and minimizing spares inventories.

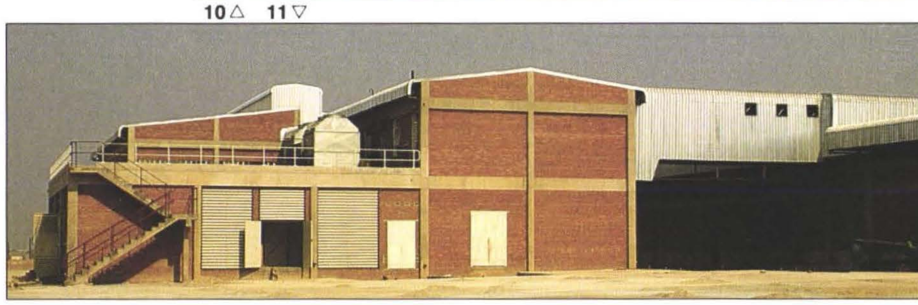
The local contracts are let under the appropriate Zimbabwean forms. With inflation in the construction industry presently running at close to 20% it was not feasible to let fixed price contracts, and price increase are paid to the contractors under local procedures. The international contracts are fixed-price and lump-sum.

By arranging the construction under many separate prime contracts CSC took responsibility for the provision of temporary services and facilities on site and for the co-ordination and management of construction. Contractors' facilities, in the form of secure compounds, latrines, kitchens and temporary utility supplies, were installed under the first contracts to be let and are maintained by the prime building contractor on site. The project consultant is responsible for co-ordination and also the management of construction work.

9 △

Projects:
9. Bulawayo
10. Harare interior
11. Harare exterior

10 △ 11 ▽



Site co-ordination

During outline design the project consultants, with assistance from the CSC team, prepared detailed programmes for the procurement and construction of each project. These programmes were set up as PERT networks and analyzed to achieve the target construction master programme.

The basic sequence of construction for each project is described by keydates in the construction master programme which define when contractors have access to particular areas of the works and when sections of the works are to be completed. The schedules of keydates and the corresponding layouts of the works areas are included with each contract and are the basis for the contractors' programming and for the subsequent co-ordination of the work.

The site management team for each project is responsible for contract administration and site co-ordination, achieved through a hierarchy of meetings from formal contract meetings down to brief informal contacts with the supervisors on site.

Training, commissioning and start-up

With the Harare and Bulawayo projects approaching completion, the CSC management team has turned its attention to the commissioning of the plants, the training of operators and the final handover of the completed facility.

Commissioning an abattoir is a lengthy process which starts with the testing of individual pieces of equipment and quickly moves on into the trial operation of the complete production line. It is during commissioning that operators are trained on the new equipment that they will be using, with careful planning needed to ensure that adequate staff continue to run the existing abattoirs.

The commissioning of the Harare Multipurpose Complex began in October 1989 with the Bulawayo Abattoir following on in February 1990. Both plants will be operational by the middle of 1990 when the commissioning of the Masvingo Abattoir is scheduled to start.

Conclusions

It has been common practice in developing countries for agricultural process plants to be procured under turnkey contracts financed by supplier credits or other bi-lateral arrangements. Through their capital development programme CSC have demonstrated that there is an alternative approach which gives the client greater control over the project and can be cheaper overall.

Credits

Client:
Cold Storage Commission of Zimbabwe

Project management consultant:
Ove Arup & Partners International

Process consultant:
Union International Consultants

Financial advisor:
Standard Chartered Merchant Bank Ltd.

Project consultants:
Ove Arup & Partners Zimbabwe
Scott Wilson Kirkpatrick and Partners

Photos:
Simon Murray

The State of the Art

Poul Beckmann

This talk was the Inaugural Lecture of the study project on Economic Recycling and Conservation of Structures at the Warren Centre for Advanced Engineering, University of Sydney, on 24 May 1989.

Poul Beckmann was the 1989 Visiting Fellow to the Warren Centre.

Before dealing with the State of the Art, the Science, and the Practice of conservation and re-use, there are some questions which should be addressed because they have a bearing on what follows. Some of these are matters which I, as an engineer, cannot claim full knowledge of, but they are questions that, in my view, should be asked.

Why bother?
Why don't we just leave it to market forces to decide when an old building should be pulled down and the site redeveloped?

Because there are structures that have become national symbols or mark an event or a period in history or an important technological development that people want to be reminded of. What would Rome be without the Colosseum or London without Big Ben?

Because there are particular buildings, groups of buildings or streetscapes, which have become familiar, have gained popular attachment and which people do not wish to see replaced by another high rise office development: mankind does not live by rent and capital gains alone!

These considerations are likely to prompt legislation/regulations aimed at securing the preservation of such structures. But national monuments apart, preservation on its own is not always practicable: we cannot afford to turn every old building into a museum piece and maintain it as such — and without maintenance, wind, weather and decay will lead to eventual collapse as surely as if the developers had had their way, even though it may not happen until some 20-30 years later. Maintenance costs money and such a building or group of buildings must therefore earn enough money to allow it to be maintained. If its present use does not enable it to do so, a new, different use may and thus aid its preservation. Such re-use may necessitate certain modifications and/or strengthening, but public and planners alike will usually look with more sympathy on this than they would on demolition and rebuilding.

Finally, there may be buildings bordering on very busy and congested streets with restrictions on lorry access during the day and prohibitions on noise during the night. In such circumstances, repair, strengthening and/or modifications to enable re-use will be much quicker and cheaper than redevelopment.

To summarize: We should conserve or recycle structures because enough of us want to — or because it may pay us to do so.

**What should be preserved?
What should be recycled?**
Clearly, single specimens of outstanding artistic merit, historical importance or technological significance should be preserved almost regardless of cost. (Some short-term economies on frills can be tolerated as long as they do not jeopardize a full restoration later.)

Good, but not outstanding, isolated specimens, that can be made to pay their way without losing their character, are likewise obvious candidates for recycling. (In many cases this will be the only way of reconciling conservation regulations with economic reality.)

And then there are buildings surrounding a square or market street, of which many may be undistinguished but which together still add up to the general ambience. Here again, recycling will help to preserve the 'feel' of the place and if it means that there is now an estate agent where there used to be a butcher, that may be deplorable, but it is the price that has to be paid for conservation of the whole.

Some buildings may be both worthy of preservation and profitable, but they happen to be in the way of a road scheme or something similar. In these circumstances it may be possible to move them to another (not too distant!) site. But when dozens of good specimens have been allowed by the planners to be bulldozed, there seems little point in them suddenly changing tack and demanding that a poor specimen, with ceiling heights that make it practically unusable, be preserved unchanged.

To sum up: in my view, we should preserve the excellent, re-use the good and well-loved, as far as we can, but not waste too many tears on the mediocre.

Who should do what?
The legislator should frame the regulations so as to make preservation enforceable. At present, in Britain, there is almost nothing to stop an owner from letting his listed building deteriorate from lack of maintenance until it becomes dangerous, at which point he can get Listed Building Consent for demolition. Damage by neglect renders the owner liable to a fine of £200 plus £20 per day: this is hardly worth pursuing and the alternative of the local authority serving a compulsory purchase order is very rarely carried out. We need much better plugs for such loopholes.

Conversely, regulations should be capable of flexible interpretation, so as to encourage conversion to new uses, even if it means the loss of one or two features of secondary importance. This must, after all, be preferable to letting the building rot.

Finally — dare one suggest? — some money ought to be found to help those who, overnight, find themselves with a listed building on their hands and are unable to maintain it in the way the listing requires and not allowed to modify it for a changed, more profitable use.

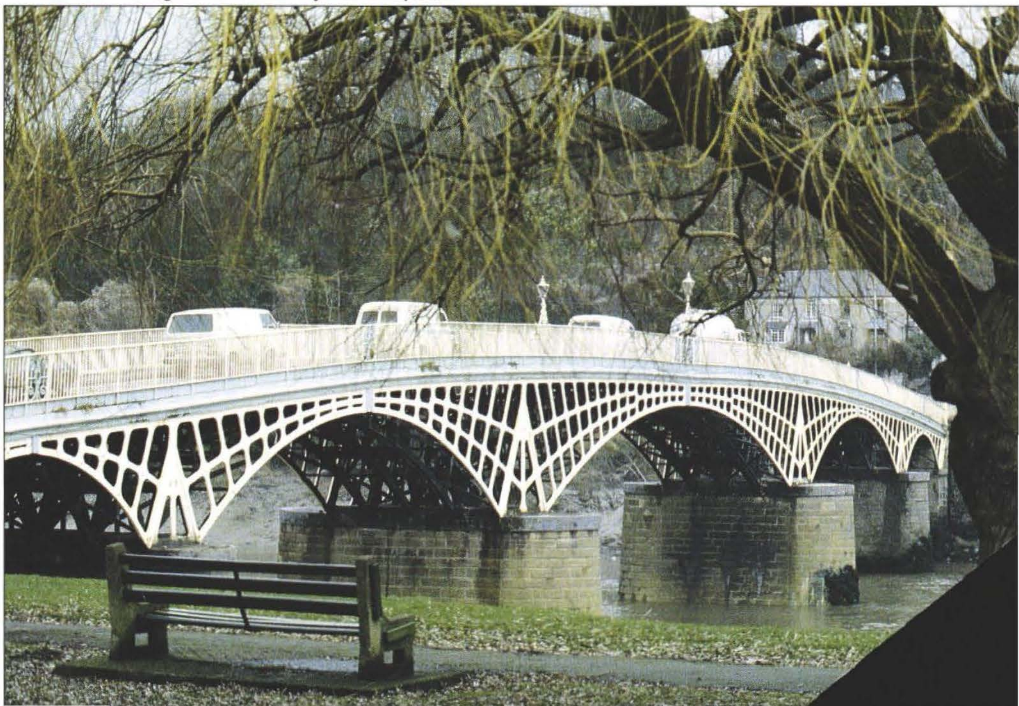
The planner has to apply the legislation. He should be discriminating when deciding on what is to be preserved. There are in Britain recorded cases where insistence on 100% preservation has led to the owners deciding to do nothing and several of the buildings in question deteriorating to the extent of having to be pulled down for reasons of safety. The planner has in this case provoked a situation of 'no bread at all' when with a little flexibility he would have had at least 'half a loaf'. The planner should be equally deaf to the developers' promises and blandishments and to the anguished protests from conservation lobbies that consider that anything from their particular pet period must be worthy of preservation regardless of its real quality. Where 'informed' conservation bodies exist, such as The Royal Commission on Historical Monuments in Britain, it will be helpful for the planner to consult with such organizations and in Britain he is required to do so.

The developer should temporarily, whilst dealing with a building that has to be conserved, forget the standard cliches about so many thousand square metres of air-conditioned office floor; instead he should use his imagination and think, perhaps, in terms of the smaller spaces of solicitors' offices, or psychiatrists' consulting rooms. He should — at least in England — capitalize on the snob value of having premises in an ancient building which may persuade tenants to pay a relatively high rent for space that may be just a little short on new-fangled technology.

There could also be another positive value of what is usually seen by developers to be a nuisance: the protected building in the middle of a site could give the tenants of the surrounding steel-and-glass boxes something pleasant to look at (especially if it were nicely restored and converted into a pub!).

The architect must respect those features of the building that are historically significant; she (or he) should tackle, as first priority, the problems that a proposed new use may pose in respect of fire precautions, noise insulation, etc. He (or she) must pay attention to the original structure and the characteristics of the materials originally used. For instance, great care must be taken when it is desired to improve the insulation of certain old buildings in some climates: extra insulation on the inside may cause interstitial condensation within the thickness of the original wall.

1. Cast iron bridge over River Wye at Chepstow.



2. York Minster: concrete extensions to tower foundations.

Any modifications must be 'in sympathy' with what is there already, and any extensions or new ancillary buildings should be compatible in terms of scale of features, but do not have to be pastiches — in fact should definitely not be: a mock-Tudor extension to a real Tudor building could make the uninformed on-looker wonder which was the real one!

All of this requires an in-depth knowledge of the architecture and construction practices of the period in which the original edifice was built. This knowledge is rarely part of the first degree curriculum of schools of architecture and, despite mid-career courses, will ultimately only be acquired by learning on the job.

The structural engineer must understand how the existing structure really works and assess its carrying capacity accordingly. He must forsake the reassuring simplifications of the standard textbooks and the intellectual crutches of codes of practice and face reality: if the structure stands in front of your eyes and has carried its working load for 50 years or more without any signs of distress, you have no right to condemn it just because your computer analysis 'shows' that it is overstressed. You have probably analyzed an incorrect model!

The engineer may on the other hand be confronted with the preservationist's stock argument: 'It has stood for 200 years, so there is no reason why it should not stand for another 200!' If his first-hand inspection and past experience tells him otherwise, he must be prepared to counter: 'It has stood for 200 years, it is getting tired and wants to lie down!' and he must explain in *layman's* terms why it is so.

The engineer must understand the nature and properties of the original materials, to what deteriorations they are liable with time and which technologies are available and appropriate for repairs and strengthening. Any strengthening that in the end is found necessary should preferably be designed to augment the original structural action rather than to relieve the existing structure of load.

Once again we are looking for skills and knowledge that do not form part of the standard university curriculum and do not figure prominently in post-graduate research: after all, there are no great profits from preserving the old to be made by any of the producers of today's materials, so why should they sponsor research? On the academic side, research into old materials involves 'getting your hands dirty', doing physical testing and the results may well be inconclusive: that doesn't make for a good PhD thesis!

So much for the 'home team' — what about 'the opposition'?

The Building Control Officer must, like the structural engineer, be persuaded to put to one side his codes and detailed regulations and look at the proposals from first principles. In Britain he is helped in this endeavour by the 'new' Building Regulations 1985 which have abandoned mandatory detail regulations and substituted performance criteria that may, but need not, be satisfied by compliance with detailed recommendations in certain 'Approved Documents'. If it can be shown that the performance criteria can be met in other ways, these will satisfy the regulations. There is also the useful '49% rule' which says that for unchanged class of use, it is permitted to replace up to 49% of floor joists with the same size as the existing, whereas if a greater proportion needs replacing, they must *all* conform to today's criteria.

(Similar ruling applies to areas of walls.)

The Fire Prevention Officer should look at the realities of the proposed re-use: what are the real fire loads likely to be? How many people can really get into the space? How easily can they get out? Most victims of fires are killed by smoke, not by flames. There are today techniques for predicting smoke movement and hence show that the number of people likely to be in the building can escape safely in case of a fire. This should help to overcome difficulties arising from rigid 'rule-of-thumb' regulations.

The contractor (who should perhaps not be listed under 'the opposition') must use materials that are compatible with the existing; he must employ craftsmen who are familiar with traditional methods of construction and have the skills necessary for the repairs that need to be carried out. As such craftsmen today are much rarer than gold dust (but a lot more use!), the contractor who wants to go in for restoration work had better start to train some himself.

The user must except the limitations imposed by any (comparative) structural weakness of the existing structure or lack of robustness of the existing materials, so as not to cause any further progressive deterioration.

The owner must undertake regular maintenance, otherwise the efforts of everyone else will have been in vain. (Restoration usually only becomes necessary when maintenance has been neglected for a protracted period!).

What has been achieved?

With the demands on the people involved, described above, one might wonder that anything ever got preserved or was re-used. Somehow or other a fair amount has been achieved in Britain and elsewhere in Europe, and judging from the attendance at the international conservation courses in Rome and York, the Americans, both North and South, have done a fair bit and want to do a lot more.

The examples that follow and which are largely drawn from my own experience may give some idea of the variety of conservation and refurbishment that has been carried out over the last 20 years and some of the methods of structural strengthening used:

York Minster[1-4] was suffering from progressive cracking in the central tower. This was caused by differential settlement between the tower pier foundations that were heavily overloaded, being originally intended for a far less heavy tower.

The remedy was to enlarge the pier bases by 'strapping' concrete blocks to the sides of the masonry foundations by means of post-tensioned rods, in holes drilled through the masonry. Almost instant effectiveness was achieved by preloading the clay under the new foundation blocks by flatjacks acting on a separate lower concrete pad. Whilst this perhaps comes more under the heading of structural strengthening than conservation, it was an operation undertaken to aid and

3. All Souls, Langham Place: refurbished interior.

facilitate the future conservation of the superstructure. Another reason for its inclusion here is that the techniques used have been found useful on a number of other projects.

Another church job, but one involving a new use of substructure, was All Souls', Langham Place[5] which needed a new meeting hall, their old one which had been rented having been sold for redevelopment. The foundations had originally been made very deep in order to rest on good soil. The new space was created by excavating the fill and replacing the old timber ground floor, which had rested on dwarf walls, by a new floor carried on steel beams spanning clear across the width of the main aisle.

In the case of York Minster, in order to remedy a potentially dangerous situation, money for the strengthening was provided by donations. At All Souls, the compensation for the loss of the old hall went part of the way towards the cost of the work and the end result was a much better hall than they had before.

4. New meeting hall in undercroft of All Souls.

Bridges are some of the most functional of structures: you can't use them for anything else! Continued use by today's motor traffic may, however, necessitate strengthening of bridges which, utilizing what was then High Technology, were designed and built for nothing heavier than the horse-drawn wagon. The bridge over the River Wye at Chepstow was built with 18 open-spandrel, latticed arch panels of cast iron. The best analysis that could be made, combined with the normally accepted working stresses for cast iron, indicated a totally unacceptable factor of safety. Samples, to give reliable and relevant test results of strength, could not be taken, due to the extreme slenderness of the ribs. Strengthening had to be provided in the form of arches of rolled steel H section, shaped to follow the curve of the lowest cast iron ribs, so as to reduce the visual impact to a minimum.

With the change in the nature and decline in volume of water-borne goods traffic, a fair number of warehouses have become redundant and a variety of new uses have been found for them: flats in Great Driffield, a hotel in Copenhagen, a restaurant in Bristol and a whole shopping and leisure centre in the huge Tobacco Dock[6] shed in London.

The major problem of these conversions is the period of fire resistance than can be provided by the existing timber and iron structural members, particularly in multi-storey buildings.

Smoke development and movement can, however, now be simulated by computer and such simulations can help to establish whether proposed new building features, such as atria, are safe.

The cases of refurbishment of office buildings are of course legion but a special prize for inventiveness must go to the architect Ricardo Bofill for converting parts of a redundant cement factory in Barcelona into a design office for his practice!

Does this catalogue of achievement mean that we know it all? By no means! We must address the last question:

What do we still have to learn?

A fair amount of work has been done on the methodology and procedures involved in appraisal of existing structures; the essence is recorded in the report by the Institution of Structural Engineers[7], but it is thought by some to be still too tied to conventional calculations and to be too conservative. The latter is partly due to our imperfect knowledge of the in situ strength of traditional forms of construction.

Despite the successful use of masonry over millenia, we do not know enough about the in situ strength of masonry: the design stresses in British and other codes of practice apply to today's materials at the age of 28 days; they are a nonsense when applied to walls built in lime mortar that may have had many years to harden by carbonation.

Whilst not always as durable, timber construction has also been with us for thousands of years and yet we do not know enough about the real strength of some traditional all-wood connections, mainly because we do not have techniques for assessing the strength properties of timber in situ.

When it comes to iron and steel, how many engineers can tell the difference between steel and wrought iron? And even if we can identify cast iron, what do we know about its strength? Most documented values relating to structural use date from the last century and show an almost alarming variability. Furthermore, the samples that one can take out of a structure are often not representative of the material, where it is actually contributing most to the loadbearing capacity.

As for recent and modern materials: Are we much better off? Do we know the real strength of steel beams, for which the makers' safe load tables quoted a working stress of 9.5 tons/in.^{2}? Have we any non-destructive tests to help us, when we cannot take enough samples for laboratory testing? How reliable are our measurements of ultrasonic pulse velocities in indicating the variation of concrete strength in heavily cross-linked columns? And — most worrying question of all — how durable are the 'patent medicines' that the chemical industry's salesmen try to persuade us to use to cure some of the ravages that time and weather have inflicted on our structures?

The purpose of this litany of our ignorance is not to spread alarm and despondency, but merely to point out that whilst the Art and Practice of Conservation and Re-use have made good progress, the Science still has a long way to go.

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(6) COURTNEY, M. *and* MATTHEWS, R. Tobacco Dock. *The Arup Journal, 23* (3), pp.6-11, Autumn 1988.

(7) INSTITUTION OF STRUCTURAL ENGINEERS. Appraisal of existing structures. ISE, 1980.

Photos: Poul Beckmann (1-4), Peter Mackinven (5)

5. Tobacco Dock refurbishment.

Cimsteel

Malcolm Shute

Introduction

The Eureka initiative is a collaborative framework to promote research and development projects between European firms. It is supported not only by the 12 EC countries, but also by Austria, Iceland, Switzerland, Sweden, Norway, Turkey and Finland. The Cimsteel project (the title is an acronym for 'Computer integrated manufacture of structural steelwork') has been undertaken in order to place the European structural steelwork industry in a leading position for the 1990s, with a core strategy of achieving computer-integrated manufacture (CIM). It has involved organizations from Denmark, Finland, France, Italy, the Netherlands and the UK, the latter being:

Trade association
British Constructional Steelwork Association Ltd. (BCSA)

Structural steelwork fabricators
Billington Structures Ltd.
Cleveland Bridge & Engineering Co Ltd.
Nusteel Structures Ltd.
Octavius Atkinson & Sons Ltd.
Robert Watson & Co.
(Constructional Engineers) Ltd.
Ward Building Systems Ltd.

Consulting engineers
Ove Arup & Partners

Research organizations
Advanced Manufacturing Technology Research Institute*
The Steel Construction Institute
The Welding Institute*
Universities of Leeds,
Sheffield* and Nottingham

Software house
Computer Services Consultants (UK) Ltd.

Some organizations, marked (*) above, will not be collaborators in Phase 2 although their services may still be used.

Ove Arup & Partners have a major role as project co-ordinators, assisting the BCSA with the management of the project. This includes project planning, progress monitoring, and technical guidance for the achievement of the project objectives. In addition, we have contributed to the full spectrum of activities ranging from, for example, the compilation of a database on machine tools, to the modelling of the design process.

The project

Cimsteel is divided into two phases. The first was completed in December 1988 and the second was due to be under way by the beginning of 1990. Phase 1 took a little over 18 months and consisted of detailed investigations of all the major elements that make up the structural steelwork industry and its market. It culminated in detailed proposals for Phase 2, which will comprise research, development and implementation of a range of co-ordinated activities targeted towards the achievement of CIM. The total European expenditure in Phase 2 is expected to be in excess of £30M, partly funded by national government grants.

Market and industry

The European structural steelwork industry is an integral part (10% in money terms) of the construction industry. It employs over 200 000 people directly and up to three times this number indirectly.

The European market for structural steelwork is estimated at 7 to 9bn Ecu per annum, representing about 5M tonnes of steel (erected). The major consuming countries are the UK (1.26M tonnes in 1988), West Germany (921 000 tonnes in 1987), France (700 000 tonnes in 1986), and Italy (610 000 tonnes in 1988).

The market share of steel as compared with in situ and precast concrete varies from one country to the next. For example, concrete maintains a dominant share in France, whereas marketing in the UK has put steel in a strong position.

Product information

At present, data relating to structural steelwork, referred to within the project as 'product information', is generally conveyed both within and between organizations in the form of paper documents. This is highly inefficient.

CIM has the goal of developing techniques and systems to enable information to be very efficiently generated on, exchanged between, and processed by computers.

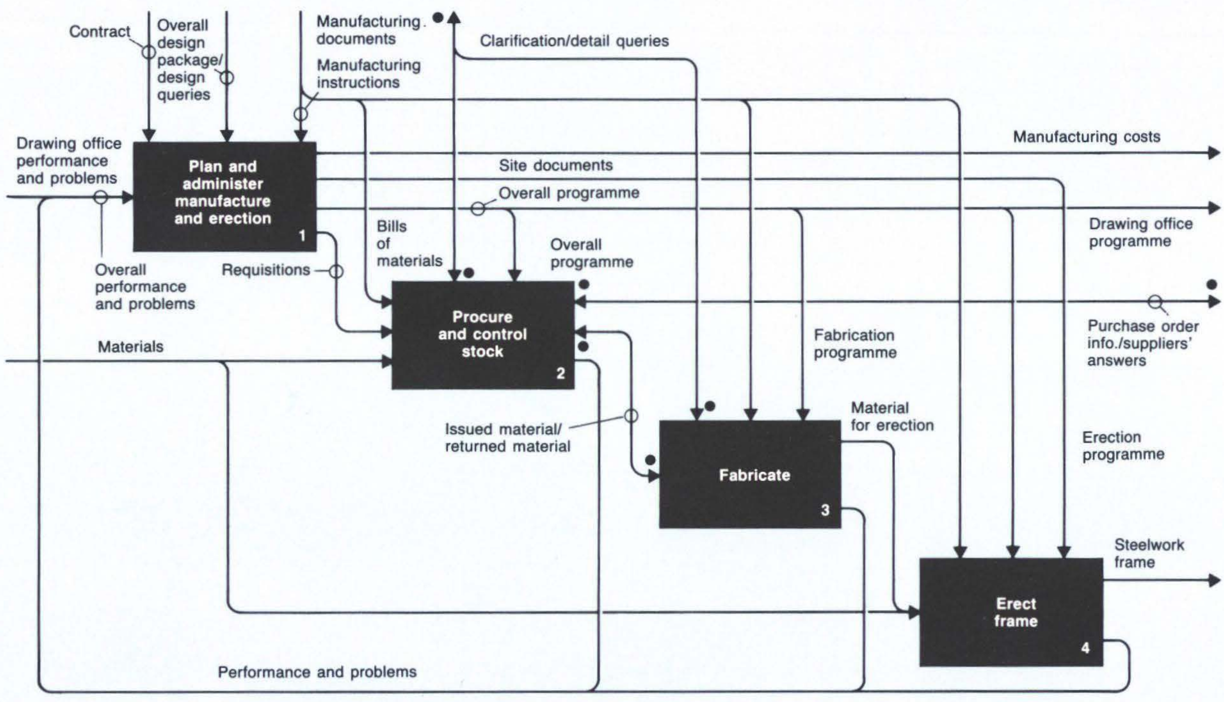
To achieve CIM, information standards must be developed. To this end, we used functional and data analysis modelling techniques in Phase 1 to unravel the complicated manner in which structural steelwork is designed, produced and erected. An example of a high level functional analysis model is shown in Fig. 1. Repeated decomposition of the higher levels enables very detailed and coherent models to be created. Extension of these models will provide the basis of the necessary information standards.

We aim to create a complete product information database which will commence with the client brief and will grow during design and manufacture to contain all information about the product. Finally the product information database, or 'product model' using ISO-STEP (International Standards Organization — Standard for the Exchange of Product Model Information) terminology, will be handed over to the client as a basis for maintenance and future modifications or extensions.

The product model will be a complete record of the steelwork structure to which, and from which, any necessary information can be added or retrieved during the design and construction processes, and afterwards.

The product information activities of Phase 2 will provide the foundations of CIM. All other developments in the design and manufacturing areas will be co-ordinated to both contribute and conform to the developing product model.

Unlike much of manufacturing industry, the construction industry is project-based where numerous autonomous organizations are contracted to work together on unique projects. The achievement of efficient working practices, and in particular the establishment of information standards, are made very difficult by the presence of contractual divides, geographical separation, incompatible systems, and conflicting objectives. This makes the structural steelwork industry a particularly difficult candidate for CIM. However, the potential benefits are great and we must tackle the difficulties.



1. A high level SADT (structural analysis and design tool) functional analysis model. SADT is a trademark of Softech Inc.

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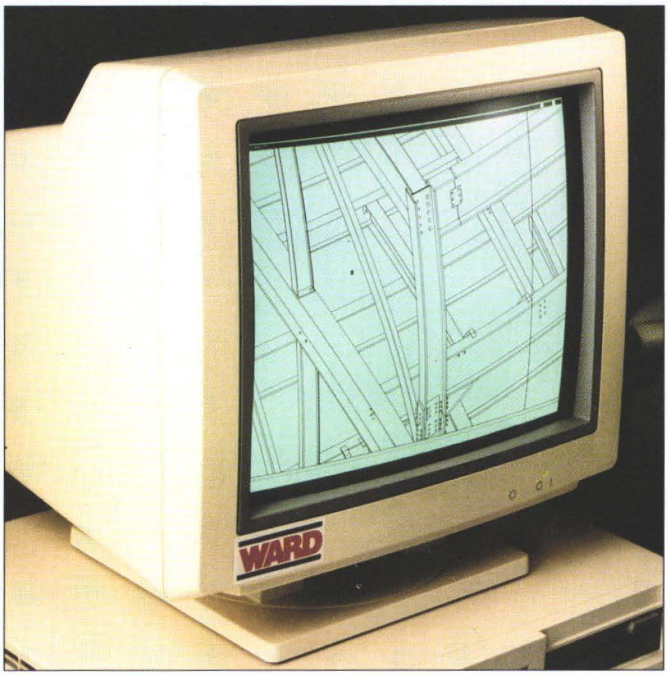

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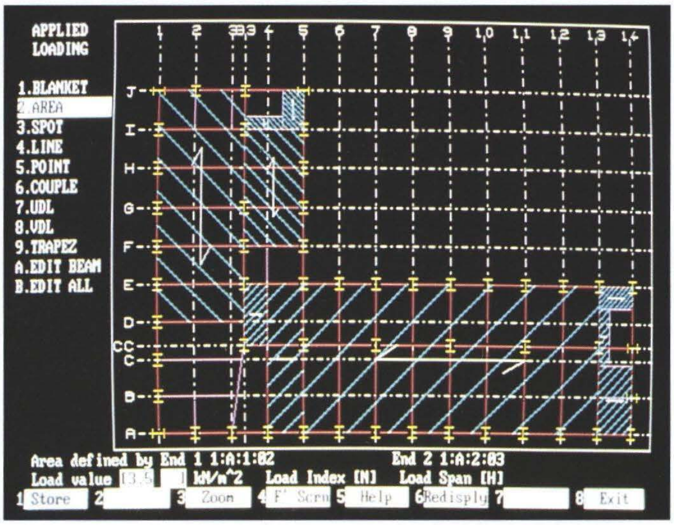

2. BOCAD in operation at Ward Building Systems.

3. Computer Services Consultants' FASTRAK design and analysis software.

4. A Peddinghaus computer-controlled machine tool.

5. The welding robot installation at The Welding Institute.

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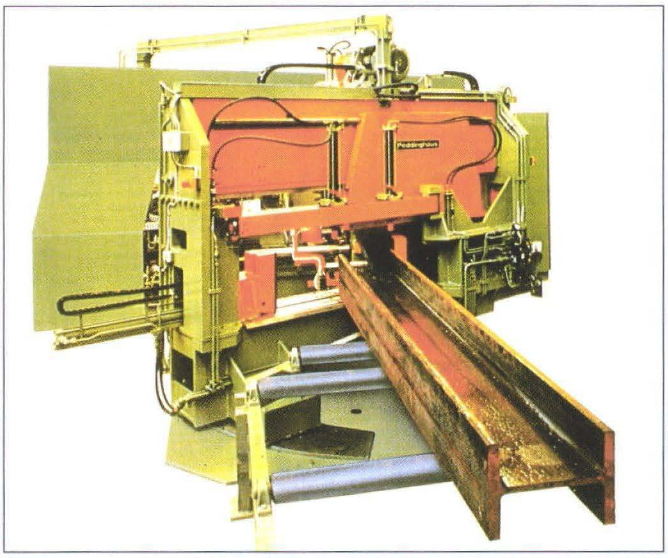

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Design

Ove Arup & Partners and fellow collaborators investigated a wide range of design topics with special attention given to standards, structural design and analysis software and to computer-aided design (CAD). One detail design system, BOCAD, shown in Fig. 2, was used to prototype interfaces between design and manufacture. BOCAD has a system of macros which is capable of automatic generation of connection details. The prototyping included the linking of a design and analysis software package, FASTRAK (shown in Fig. 3), with BOCAD to carry out the design, analysis and detailed design of a two-storey steel structure in a fully computerized manner with direct digital transfer of all information.

In Phase 2 we will not only produce improved design and analysis software which will be compatible with the product model, but will also strive to create a European environment in which standards and design models are amenable to efficient computerized solutions. Thus, the Phase 2 design activities will primarily concern:

- Unified European design models based upon Eurocodes 3 and 4.
- Design and analysis software compatible with the product model, including software modules for connection design.
- Adaptation of standards to facilitate computerized solutions.
- Software certification procedures.

Manufacture

There are no structural steelwork manufacturers in Europe making full use of the latest computer-controlled machine tools available from suppliers such as Peddinghaus, Kaltenbach, Trennjaegar, Ficep and Promat. Where machines like the one shown in Fig. 4 are in use, they are not integrated into the wider manufacturing process and maximum benefits cannot be achieved. The weakest elements of the production process are materials handling and welding. Phase 2 will carry out research and development into both of these areas.

The linking of computer-aided design (CAD) and computer-aided manufacture (CAM) is a key requirement for CIM. A mock-up of a CAD/CAM link between BOCAD and a number of computer-controlled machine tools, including a welding robot, was successfully carried out in Phase 1. Fig. 5 shows GRASP software in use at The Welding Institute to simulate and programme the welding robot visible in the background.

A key activity in Phase 2 will be the production of a modular manufacturing information system (MIS). This will incorporate both improved computerized management techniques for planning and control of the manufacturing operation, as well as providing the mechanisms for integration of CAD with the direct digital control of machine tools and their associated production processes. We will develop the MIS to be compatible with the product model and it will provide an essential element of the future CIM system.

As in design, the manufacturing activities will address wider issues, including the development of a European quality assurance system and a European structural steelwork specification.

The future

Phase 2 will take four to five years to complete and will in itself go only part of the way to achieving CIM. The path towards full implementation will be progressive both within individual companies and within the industry as a whole.

It is accepted that technological innovation has a major role to play in ensuring long-term survival and that investment in better equipment and systems is essential to keep up with the competition, wherever it may come from. By undertaking this ambitious Eureka project, the structural steelwork industry and its wider construction industry partners are actively pursuing a bright and profitable future.

Credits

Clients:
Department of Trade and Industry
BCSA

Photos:
2. Ward Building Systems
3. Computer Services Consultants
4. Press & Shear Machinery Ltd.
5. The Welding Institute

1989 Awards and Commendations

Ove Arup Partnership have been associated with the following:

European Steel Design Award

1. *Broadgate Phases 1-4*
Arup Associates Architects + Engineers + Quantity Surveyors

Carpenters Award
(Hardwood section)

2. *York Minster restoration*
Architect: Charles Brown,
Surveyor of the Fabric
Structural engineer: Ove Arup & Partners

(Glulam section)

3. *Private House, London NW5*
Architect and client: Richard Burton
Geotechnical, structural and services engineers: Ove Arup & Partners

David Urwin Heritage Award
(Winner, New Buildings Section)

4. *New Court, Fitzwilliam College, Cambridge*
Architect: MacCormac
Jamieson Pritchard & Wright
Structural and services engineers:
Ove Arup & Partners

1989 Housing Awards *(Joint National Winner)*

5. *Collingwood Court, Morpeth, Northumberland*
Architect and client:
David and Jane Darbyshire
Foundations and general advice:
Ove Arup & Partners

Financial Times Architecture at Work Award *(Commendation)*
Industrial Agents Society Development of the Year Award

6. *Stockley Park*
Arup Associates Architects + Engineers + Quantity Surveyors
Civil engineering and transportation consultants: Ove Arup & Partners

Financial Times Architecture at Work Award *(Commendation)*

7. *Princes Square, Glasgow*
Architect: Hugh Martin & Partners
Structural engineer: Ove Arup & Partners Scotland

British Construction Industry Awards *(Commendation, Buildings Section)*

8. *5 Longwalk Road, Stockley Park*
Architect: Foster Associates
Structural and services engineers:
Ove Arup & Partners

Brick Development Association Quality Brickwork Award *(Greater London Regional Winner)*

9. *London Scottish Regimental Headquarters*
Architect: T P Bennett & Son
Structural engineer: Ove Arup & Partners

Structural Steel Design Awards

10. *Imperial War Museum Extension*
Arup Associates: Architects + Engineers + Quantity Surveyors

11. *National Exhibition Centre, Halls 6, 7 & 8*
Architect: The Seymour Harris Partnership
Civil, structural and building services engineers: Ove Arup & Partners

(Commendation)

12. *CAA HQ, Gatwick Airport*
Architect: Fitzroy Robinson & Partners
Structural and services engineers:
Ove Arup & Partners

RIBA Regional Awards
(East Midlands region)

13. *Next Headquarters, Enderby, Leicestershire*
Architect: ORMS Architects
Structural engineer: Ove Arup & Partners

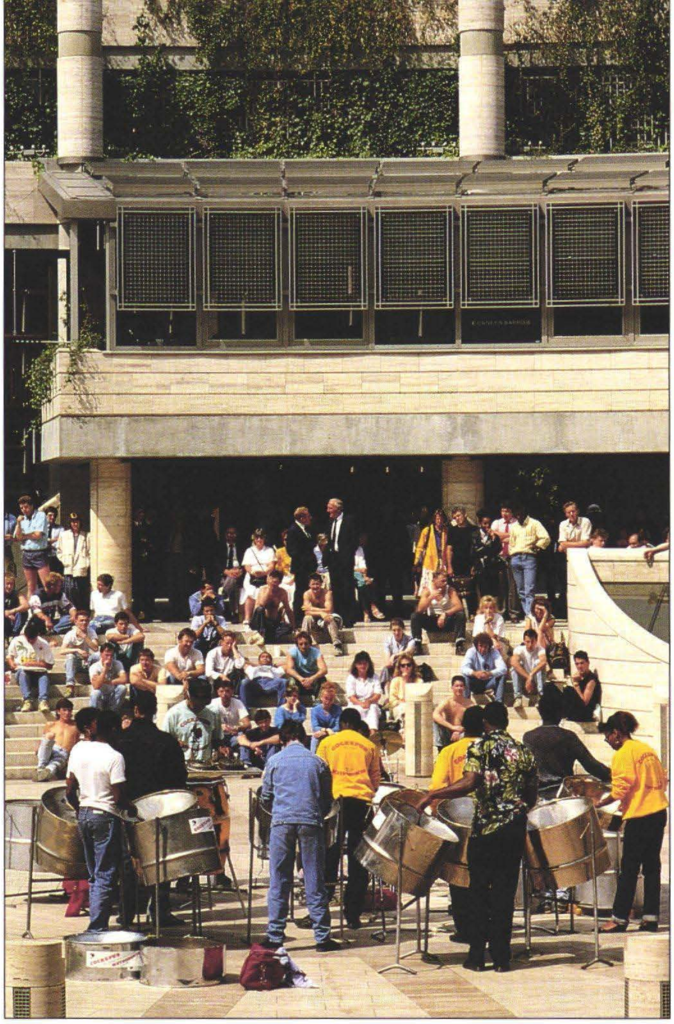
(London region)

14. *Billingsgate Market Refurbishment*
Architect: Richard Rogers Partnership Ltd
Structural and services engineers:
Ove Arup & Partners

British Construction Industry Awards Commendation: *(Civil Engineering Section)*
Institution of Civil Engineers South Wales Branch Design Award

Chepstow Inner Relief Road and Bridge
(Back cover)
Architects: Alex Gordon & Partners
Wyn Thomas & Partners
Civil and structural engineers:
Ove Arup & Partners

The 1989 Civic Trust Awards will be featured in the Spring 1990 Arup Journal.



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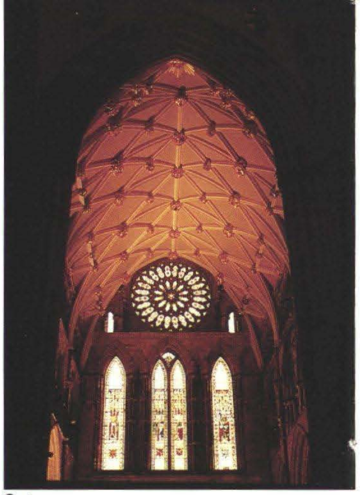

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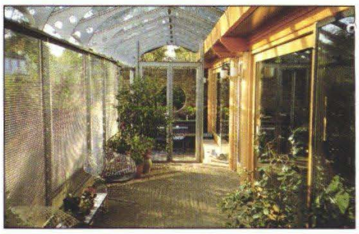

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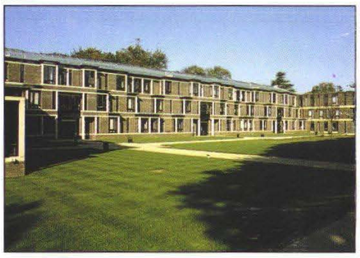

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Photos:

1.	Arup Associates	7,11.	British Steel
2.	Peter Ross	8,14.	Peter Mackinven
3.	Ahrends Burton and Koralek	9.	Chris Hollick
4.	Ove Arup & Partners	10.	Peter Cook
5.	Jeremy Preston	12.	Fitzroy Robinson & Partners
6.	Crispin Boyle	13.	ORMS Architects

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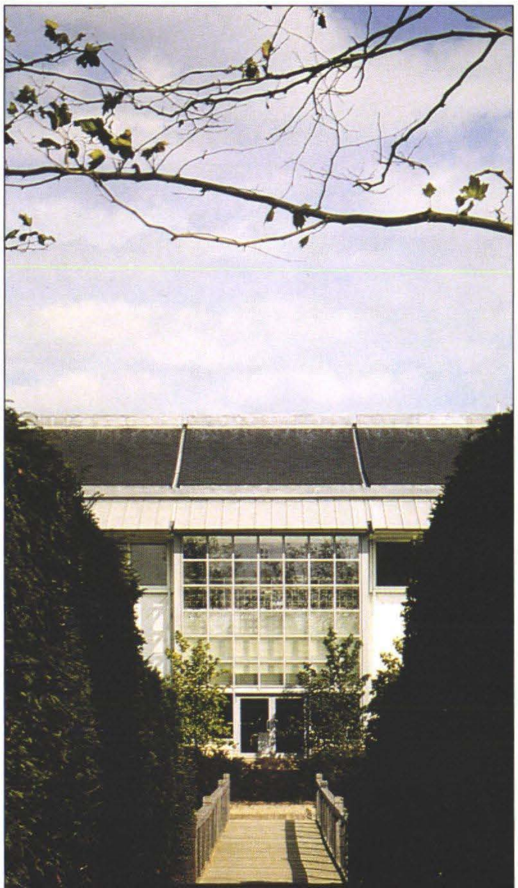

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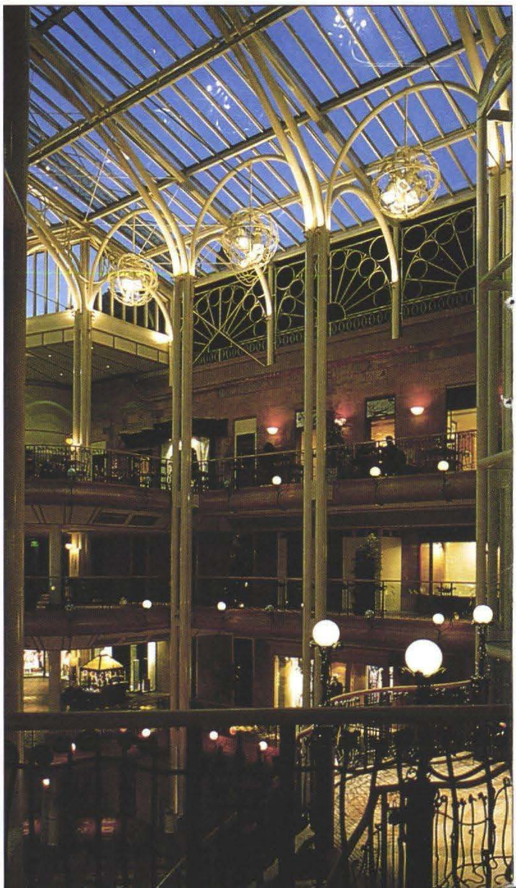

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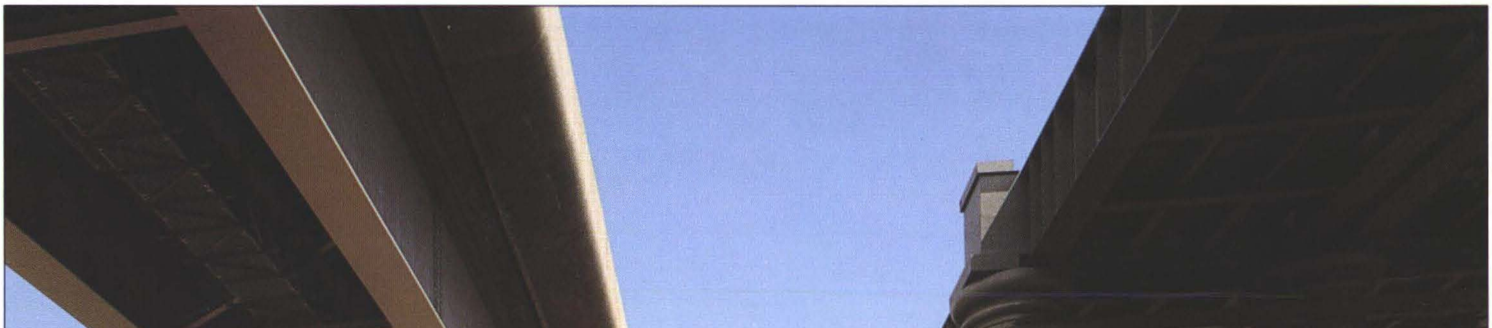

Peter Dunican

1918 - 1989

Peter Dunican, who probably more than anyone, other than Sir Ove Arup himself, shaped the fortunes of our firm into what it is today, died on 18 December 1989. His presence among us was a constant reminder of the early development of Arups and the principles on which our culture has been built. His passing takes away from us much of the physical embodiment and reminder of our early history.

Peter Thomas Dunican was born on 15 March 1918 in Surbiton, Surrey, the only son of a Scottish mother and an Irish father. Although by residence and affinity a Londoner through and through, his Irish heritage, both by natural attraction as well as sentiment, played a significant role in his life. It was to find particular expression in his contribution to and involvement with our Irish offices.

Peter was educated at the Central School, Clapham. He left school in 1935 to work in the Battersea Public Library. Whether or not this experience imbued in him a zeal to learn and acquire information or whether his thirst for knowledge was innate, his prodigious interest in books and information in general was a lifelong passion.

In 1936 a friend induced him to join S.H. White and Son, Consulting Engineer, as a trainee engineer. At the same time he went to the Battersea Polytechnic to study engineering, attending evening classes to obtain the education necessary to enable him to sit the graduate and subsequently the associate membership examinations for entry to the Institution of Structural Engineers. Day release schemes, let alone sandwich courses, were not available at that time. Most engineers entered the profession through part-time study in order to satisfy the entry requirements of the professional institutions.

What will come as a surprise to many is that Peter in these, his younger days, was an enthusiastic and competent sportsman. A friend and colleague of those early days described him as being 'positive and energetic in his games . . .' and that his sliding tackles as a halfback playing football were feared by many opponents.

He stayed with Whites' until 1943, when he joined Ove Arup in what was then called Arup & Arup Ltd., a firm of contractors as well as designers of mainly civil engineering works. (Peter's eyesight had precluded him from service in the armed forces in World War II.) When Ove left Arup & Arup in 1946 to set up his independent consulting engineering practice, Peter went with him.

In many ways from then on, the history of Arups is a history of Peter Dunican. Ove was the inspiration, the philosopher, the progenitor of the modern structural engineer as a creative collaborator in the design of buildings, rather than an analyst who merely ensured that tried and proven solutions were checked for appropriateness and errors. Peter was the person who over the years made it happen, made it possible to create and develop a firm quite apart philosophically as well as physically from the existing Victoria Street establishment. Although both were born in England, neither Peter nor Ove was strictly speaking English, so that the non-conformist ideas and principles on which our firm was built had more to do with their respective personal attributes than with their backgrounds. Both were rebels in the nicest sense of the word.

Professionally, Peter was attracted to what he called 'socially useful' building — housing, schools, universities, hospitals — and it was in the design of mass housing that Peter's technical expertise and social conscience converged. His passion for the need to improve the nation's housing found a natural outlet in his contribution to mass housing and in particular their structures.

Hundreds of thousands were ill-housed, largely though not totally as a result of the devastation caused by World War II. Ove had introduced some novel ideas in the use of reinforced concrete to housing just before the War. Peter took these ideas, built and developed them to the stage that, when the Government in the '60s decided to support the fledgling industrialized building market, he had secured for Arups a prime position where our expertise both as designers as well as appraisers of building systems was unchallenged. That the efforts then made were unsuccessful in solving the housing problems and that a backlash against multi-storey housing eventually resulted has nothing to do with the basic ideas and concepts, which were sound. They have proved to be successful in most other countries and were misapplied in this country. Peter never lost his belief in the concept of industrialized building as a means of solving the housing shortage — and there are signs that his belief will in one way or another be fulfilled.

Peter became a member of the Institution of Structural Engineers in 1946, an Institution he was to serve with such distinction. He became a Vice-President in 1971 and was President in 1977/1978. He worked tirelessly for the Institution, often challenging the conventional wisdom, always ready to speak out for what he thought to be right and eagerly advancing the cause of the engineer and the structural engineer in particular. In the special 70th birthday tribute to Peter Dunican published by us, Cyril Morgan, who was the Secretary of the Institution during Peter's term of office, said '. . . No man is a hero to his valet . . . but some Presidents can command the real affection of Secretaries of chartered engineering institutions. And so it was with Peter . . .' There can be no finer tribute than that. The Institution awarded Peter the Lewis Kent Medal in 1984 for personal services to the Institution and the profession.

He was made an Associate Partner of Ove Arup & Partners in 1949, a full Partner in 1956 and, after the firm was reorganized in 1977 to become a partnership of two unlimited companies, became the first Chairman of Ove Arup Partnership. He had been chairman of the old partnership meetings, but this was the first time that his position was formalized. He was also Chairman of The Arup Partnerships since their formation and retained both positions until his retirement in 1984. Since then he had acted as consultant to the practice.

Peter's interests were wide and varied. His prodigious drive and energy allowed him to contribute widely to the construction industry. As early as 1957 he served on the County Council's Advisory Committee on the London Building Acts and By-laws. He was on a Ministry of Housing Working Party to revise the Model Building By-laws in 1960, on the Building Regulations Advisory Committee from 1962 to 1965, and the Council of the Architectural Association 1968-69. He was Chairman of the Ground and Structures Research Committee of the Building Research Station, he served on the Civil Engineering Committee of the Science Research Council 1968-71, and was a member of the Joint Consultative Committee and Chairman of the Joint Building Group from 1973 to 1976. He was elected to the Fellowship of Engineering in 1978 and was a Member of Council from 1983 to 1986. He was created a CBE in 1977.

His great interest outside Arups, however, other than the Institution of Structural Engineers, was in the National Building Agency which was set up by the Labour Government in 1964 '. . . to help the industry to deal with the great upsurge of demand now facing it. This it will do by encouraging productivity both in traditional and industrialized building . . . etc.'. Peter was a part-time director of the Agency from its inception until 1978 when he succeeded Lord Goodman as its Chairman, a post he held until 1982, when he was asked by the Government to wind it up. There was no better exemplar of what Samuel Smiles meant when he wrote, 'Those who have most to do and are willing to work will find the most time'. Peter was selfless in giving his time to the industry or to causes in which he believed.

But it was his love for and service to Arups which we must celebrate and which has enriched our lives immeasurably. He had an instinctive understanding of structures. He personally designed or led the design for many significant projects. Housing schemes, each of many hundreds of units, bear witness to his interest in, and developing solutions to, housing problems. He was personally responsible for our work on the Barbican Redevelopment, on the National Sports Centre at Crystal Palace, the Stock Exchange Building in the City of London and the new University of East Anglia. He developed a lasting interest in soil mechanics from the time when it was the fledgling of the several disciplines which go to make up civil engineering expertise.

His technical achievements were substantial, but equally his indirect contributions by helping others, his astute comments, his support when the going got rough, were invaluable. Many of us remain grateful for his time and consideration. Much of our culture is a direct result of his contribution. The concept of equal partnership, non-shareholding partners and ultimate ownership being vested into trusts, owes much to Peter's beliefs and initiatives.

His outstanding achievement, however, was the creation of the framework, the systems which form the basis whereby we carry out our work today. The Staff Office was his creation; the administrative machinery which enables us to carry out our work as freely as possible was established and developed by Peter; but his greatest contribution was probably the establishment of our Library and information systems. Information, its acquisition and distribution, was a lifelong interest and the Library, its people and functions featured high in Peter's priorities. He personally never lost a boyish enthusiasm for the acquisition of knowledge and the Library played a large part in fulfilling this drive.

His door was always open to anyone who needed help or advice. No problem was too small or mundane to warrant his attention. If you needed help you went to Peter. If you wanted something done you went to Peter. When you were at the other side of the world the only way to be sure that your needs were met was to phone Peter. No-one was turned away. That is not to say that he was saintly — his tongue could be sharp if he thought you had transgressed, but never in a hurtful or lasting manner. 'A clip around the ear', he used to describe it with a laugh. He was a natural leader who, by example, inspired others to great achievements, commanded respect and affection, and was himself equally loyal and steadfast to friends and colleagues.

He gave particular support to certain practices abroad — Ireland, Nigeria and Zambia. He was a jovial man whose interests were wide, soaking up facts on many diverse and disparate topics. His memory was lethal at times — he remembered matters which were best forgotten! He liked company, was always ready for a discussion, if not an argument, and was popular with colleagues inside and outside our firm. All in all — to quote Cyril Morgan again, 'A lovely man . . .'.

He read widely and he was particularly interested in politics. He enjoyed music and going to the opera. But, family apart, his life was primarily and in single-minded fashion devoted to Arups and the construction industry.

He married Irene in 1942. They were happily married for 47 years and she supported him generously during all those years he gave to us and the industry at large. She survives him as do his three children and four grandchildren. We shall miss him. They don't make them like that any more.

Jack Zunz

Photo of Peter Dunican by Harry Sowden