THE ARUP JOURNAL

TENTH BIRTHDAY ISSUE

JUNE 1976


THE ARUP JOURNAL
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THE ARUP JOURNAL

Vol. 11 No. 2 June 1976
Published by
Ove Arup Partnership
13 Fitzroy Street, London, W1P 6BQ

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Art Editor: Desmond Wyeth FSIA
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The first ten years; a personal view

Peter Dunican

This is the 10th birthday issue of *The Arup Journal*. It is intended to be a tribute to everyone who has helped to make it what it is and in particular to all the members of the editorial staff, who have worked on it since those rather heady days in 1966 when No. 1 was published and when so many other exciting things were happening. Also this issue is a special recognition of the contribution made by the two editors of *The Arup Journal*, Rosemary Devine and Peter Hoggett, who so successfully established the Journal and made it one of the best technical quarterlies published in the United Kingdom today. And this I suppose is now the central difficulty which confronts us: how to maintain and improve on the standard which has been set?

In the beginning we had the *Newsletter* and this inevitably exposed the need for *The Arup Journal*. As I have said before it was intended that the Journal should be an entirely technical publication and that the editor should have complete responsibility and authority for its contents. Of course, there is a double-edged freedom which goes with this sort of responsibility, and it is extremely encouraging to observe how successful the editors have been, particularly as neither of them is an engineer!

But I must say that I am much more interested in the future than in the past, and here I would like to see a greater inclusion of theoretical work in the Journal, although I must admit that the papers which appealed to me most have been much more discursive than technical.

It would be foolish, and possibly invidious, to say what I thought was the best paper which has been published to date. Certainly, the one which stands out in my mind was that by David Mitchell about York Minster. The form and content of the paper were quite outstanding. Perhaps the subject was one of more universal appeal; no doubt it was exciting and there are a number of awards to confirm this, not least of all the Beckmann–Dowrick paper which won the Telford Gold Medal.

Possibly the most significant issues have been those which have been devoted to single subjects, for instance the one on the Sydney Opera House was outstanding and more than did justice to the subject. On the other hand, and with prejudice, my favourite must be the special issue for the firm's 25th anniversary, although perhaps on reflection it could have been less personalized. This is another delicate balance for the editor to maintain.

And so it is with the covers, which certainly give scope for editorial imagination, wit and percipience. The choice of covers is a very emotive and a very personal subject. Personally one of the most satisfying covers was of my piece of sculptured, industrialized, architected ironmongery made out of steel window section off-cuts, but perhaps here I was influenced too much by the primarily housing content of the issue.

However, prejudice apart and on a more impartial plane, perhaps the first cover was the best, even if it was the most obvious. We had to borrow Max Fry's Gold Medal to bring it off, but fortunately the Queen's Gold Medal for Architecture is not personalized by any engraving, but even if it had been I am quite sure the editorial staff could have even dealt with this; difficulties existed to challenge them but not to deter.

Those which I have liked best have always had some relevance to the contents either in a contrasting or complementary manner. Here I am very much reminded of the outstanding pre-war monthly *Lilliput* which unfortunately is no longer with us.

The success of the Journal has also been ensured I believe by our art editor, Desmond Wyeth, whose technical skill over the last 10 years has had such an impact on the development of the Journal. Form is as important as content as we all know, and even more so when content is interpreted as function and structure. Here also the special contribution of David Brown must be acknowledged.

I do know that not everyone will agree with me either about the Journal or anything else for that matter. At least one of my colleagues still believes that the Journal was much better before it was so named, when it was typed, duplicated and stapled with its own imaginative dye-lined, tea-chest stencilled, pre-natal *Newsletter* cover; nostalgia can be taken too far!

I am not sure how the 20th birthday of *The Arup Journal* will be acknowledged but I am quite certain that if we continue to maintain our aims and objectives and confirm and reinforce our notions of editorial freedom and responsibility embodied as they have been in the past through such able editors we really do not have anything to worry about.

But, as I have said before, no matter how skilled and able are the editor, his staff and his advisers, in the end it is you and what you do which makes the Journal. It is produced for you and it can only survive if you produce; please do not think of what the Journal can do for you but rather think of what you can do for the Journal.

It may well be that 1966 and thereabouts was an heroic period in the life of our firm, and that the publication of the Journal could not have started at a more propitious time. Nevertheless, we do have even more heroic days to come and we must be ready to respond to them. The future lies with you.

Our inheritance, the next step?

Philip Dowson

This paper was originally given as a talk to a joint meeting of the Building Services Engineering Society, the Joint Building Group and the Junior Liaison Organization, at the Institution of Civil Engineers on 30 October 1975.

I was asked to give this talk with particular reference to Architectural Heritage Year because our practice has been concerned for some time with the rehabilitation of old buildings for new uses and, as it was also put to me, we have been concerned with designing new buildings to fit into the fabric of old historic sites. The title of my talk – 'Our inheritance, the next step' – is, of course, an enormous subject, but a talk has to have a title. It gives me, however, the opportunity to dwell and observe on some aspects which have been pre-occupations of ours. I make no apology that I should look at these through the eyes of an architect – not an historian or theoretician – and I shall talk unrepentantly from what may appear a rather architectural point of view, if simply to avoid the kind of discussion which can so rapidly become the shape of an inverted pyramid – not an unreasonable shape for an architectural discussion, one might add, for those who may think we are prone to seeing things upside-down.

I believe Architectural Heritage Year marks a watershed in a number of ways:

(1) The public is at last waking up and protesting at what is happening to our environment.

(2) Our resources are being examined in a new light and in new ways.

(3) For many the Modern Movement has turned sour.

(4) The designers are losing their nerve and tending to revert to a reactionary position of safety.

(5) There is a recognition of the need to conserve and re-use much of our building stock which we have been too ready to destroy without reason.

(6) The failure of much comprehensive redevelopment – in Jane Jacob's words, 'Cataclysmic Change' – and the recognition of the need for blood transfusions rather than transplants. It is easy to raze an area of a city and rebuild it in a matter of years, but what of the social infrastructure that is lost? That will take generations to heal.

(7) To quote Theo Crosby – 'There is an appalled realization that we have unwittingly lost irreplaceable treasures, discarded irrecoverable aesthetic and social pleasures for the benefit of an ephemeral technology.'

There is indeed a crisis in architecture.

Two years ago, at the JLO Conference in York, I made the point that public criticism, in step with mounting concern over conservation, and a healthy dislike for much that has been happening to our cities, towns and our countryside, will be increasingly directed towards the environmental professions who are, in their view, largely responsible. We *can* argue that society gets the cities and architecture it deserves; that economic considerations pre-empt to a large extent the results that all of us deplore; that organizations are too often indifferent to architecture, or at any rate disinclined to accept it until it has first been disinfected by financial propriety. Nevertheless, in the meantime, the centres of great cities have been disembowelled. Redevelopment has too often become synonymous with destruction. The scale of buildings has become so large as to be out of reach of ordinary mortals, and the inhabitants have become alienated and the places unloved. This, I believe, remains true.

So the environmental professions have a formidable problem of bridge-building to undertake between the public and themselves.

We are viewed at present like a pack of hounds that have lost the scent or, to change my metaphor, the architect as the conductor is seen to be working from one score while the orchestra is too often playing from another. There is the deep, and not unreasonable, suspicion that any specialists, if left to themselves, are inclined to seek solutions drawn too largely from within their own specialisms. This is a question of ends and means. Because of the very excitement of the limited professional or technical chase, it is easy to overlook the purpose of the hunt. The means are so fascinating that we become seduced by them. It is a moot point to what extent we are willingly misled by the siren songs of technology, or hijacked against our better judgement by its imperatives. Both are evident.

So it is not perhaps surprising that, through lack of confidence or understanding, or both, administrations and bureaucracies fall back on proliferating rules and regulations. Of course, regulations are necessary, but I believe the best games are usually played with fewest rules. As Peter Martin also said at York in another context – 'We have to beware that the present righteous indignation of the public does not result in a rash of legislation which is only half thought out, academic, and unlikely to achieve the stated objectives. The professions have to be *much more* on their guard than they have been in the past, otherwise their imprisonment will become more *rigorous* within a system which they *ought* to take part in leading'.

Fig. 1
Canaletto's Venice – the nearest thing to an 18th century photographer that we have

Design, however, needs good designers, as well as an active public interest, and this purpose will not be served if the designers are submitted to such great pressures that they either lose their nerve altogether or have it gradually eroded. This risk is very real. As designers, we *have* to be excited by the prospect of what can be achieved and, for this to be the case, we *have* to be secure in the knowledge that *what* we are trying to achieve is relevant to the public, or our client's, interest. As designers we need encouragement, just like anybody else if we are to succeed, and that needs understanding on the part of our patrons as well, who, if this is to be the case, must in turn be secure in the knowledge that we are working competently and professionally in their *real* interests, although they may feel, from time to time, that they are taking their life into their hands and are bound on something of a mystery tour.

WATERSHED

We are then, I believe, at a watershed.

Architecture at the moment is subject to a large number of movements which reflects its dilemma. It is an art, a craft and a science, but on the whole the art has recently been at odds with the science and the craft has been disappearing. As an architect, I am worried that I am continually being asked to solve increasingly impossible problems, with a danger that better techniques will merely make it possible to support and extend the life of otherwise obsolete ideas, rather than to find an application for new and perhaps more appropriate ones.

Whether we have failed the Modern Movement, or whether it has failed us, is perhaps another discussion. But the re-assessment and soul-searching that is going on at present must not be a retreat but an attempt to focus more keenly. It is inevitable, I suppose, that we have had to go through the various phases we have experienced in the last 50 years. In observing, for example, on the Modern Movement's elimination of all decoration and embellishment from buildings, in pursuit of social aims within an industrialized society, it is interesting to note how rapidly these social aims, and the process of elimination, generated a strong aesthetic compulsion of its own. This went closely in step with the painters and sculptors of the time, and it soon achieved a very distinctive style. This style, however, in company with what the Movement fundamentally represented, was debased and exploited after the last war, and has become associated in the public's mind with 'Modern Architecture' and with the reconstructed devastation – what else can it be called? – of large areas of our great cities. The public is protesting, the money is running out, and so the sacking has to stop.

OUR INHERITANCE

Consider Venice, not only for what it represents but also because it is so relatively little changed. A city always of tourists and merchants, it has been so carefully and methodically recorded by Canaletto, who was the nearest thing to an 18th century photographer that we have. We can check how accurate he was, and therefore have confidence in the accuracy of his paintings of London, which I shall come to presently. No questioning then the integrated skill of the architects, civil engineers, craftsmen, artists, or very particularly, the level of enlightened patronage. There were no planning authorities as such then, just a social acceptance that if you built you tried, for whatever reasons, to add to the beauty of the city. (If not, you could run foul of the authorities and be found buried head down with your feet sticking out of the pavement of St Mark's Square!). Craftsmen rarely *waste* their materials, and those who worked in this city, and built it over the centuries, seemed to have been as *mindful* for its site and its spaces, as the craftsman is for his materials.

In this respect it is also important to recognize that the simple human gesture of reassurance – to touch – to feel – to handle, to which any pilgrim church bears witness, is basic. Whatever other architectural aspirations there may be, the need for reassurance at this elementary level should surely be self-evident; that is, if a secure relationship is to exist and alienation is to be avoided. Indeed, whatever else Venice may be and represent, it is also a supremely tactile place. You can actually *handle* Venice anywhere as you walk, as you could have done with London in Canaletto's day.

London was called by 18th century travellers 'the jewel of Europe'. This was not designed by a swarm of architects – but, by and large, by builders working within a tradition. Cities represent the physical embodiment of the attitudes and values of their societies, of which they are the clothing. Most of these buildings, constituting the fabric of the city, were the result of traditional crafts, aided by pattern books and effected, of course, by the swing of fashion, which in turn stemmed from the great patrons, and the few architects who were employed by them (and I am always being told that they have usually been a cussed lot). As Sir Christopher Wren himself remarked – 'Architects are as great pedants, as critics and heralds'.

I would like to dwell for a moment on this vernacular aspect, as the greatest part of our inheritance is traditional vernacular architecture, architecture without architects, which has evolved almost like a species, with time to embody and reflect the countless pressures of social pattern, climate, economics, transport, materials, techniques and so on, as well as the fashion and style, which invested these great traditions in the past. Traditions where the appropriate and the preferred survive, a kind of Darwinian theory of building design evolution.

Fig. 2
Canaletto's London

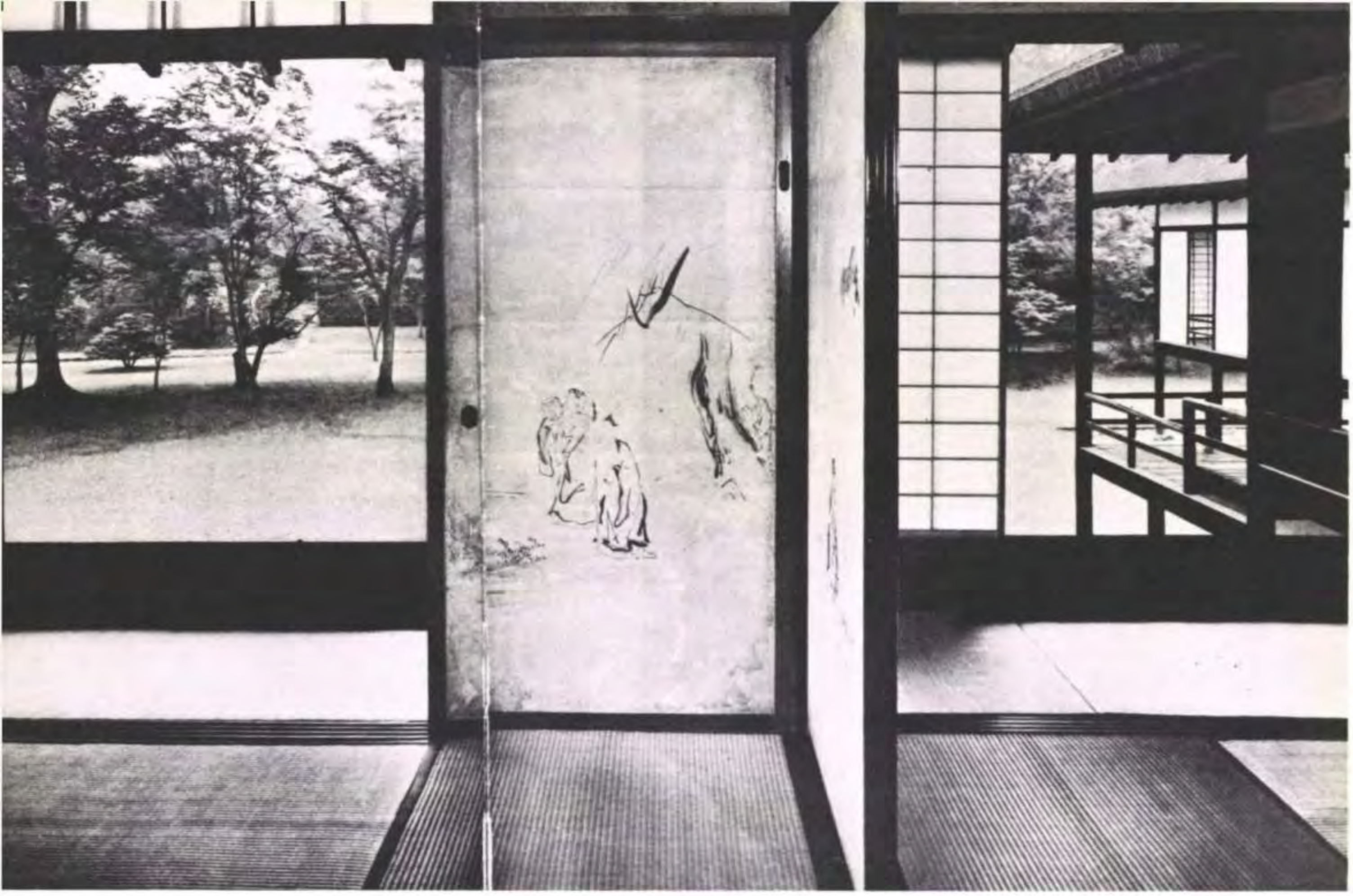


Fig. 3
The Katsura Imperial Palace

Fig. 4
Mies van der Rohe's
Illinois Institute of Technology

It is worth reflecting on the richness that these traditions derived from apparently such simple means, and the manifest delight in natural materials which they exhibit. Also, recognize the discerning eye and thinking hand of the craftsman, and the language of construction, which testified to such a humane approach, and at times such a highly sophisticated architectural result. It is an achievement which, to a remarkable degree, combines a coincidence of thought, feeling, understanding and method. As Leonardo da Vinci remarked, 'When the spirit does not work with the hand, there is no art'.

What so many of these vernacular traditions had, and what we seem to have lost, is the art of designing in an intimate way, or for that matter in a monumental one, which still embodies the kind of scale which is interesting to the eye and, particularly, acceptable to the touch, so that in approaching these buildings

we naturally use them (Fig. 5). We lack a satisfactory grammar of detailing derived from the way we make our buildings, which is implicit in the result, or a decorative tradition which can reinforce and emphasize that which is basic to a design. Decoration, please, which elucidates and does not obscure the design idea. We badly need the delight and interest of intelligent and imaginative detail in our modern buildings. It is also increasingly difficult to achieve, the designers having to work more and more via remote control, within an industrialized context.

However, when one examines any vernacular design, it is immediately apparent that the inter-dependence of the various designers and craftsmen working within the tradition was taken for granted, and their individual contribution was appreciated and understood by each other. Indeed, it *must* have been so to have achieved the results which they did.

Fig. 5
Chester Shopping Centre – 'interesting to the eye – approachable – to be naturally used'

Fig. 6
Pedestrian shopping centre – 'the simple human gesture of reassurance – to touch – to feel – to handle' – *but* HOW and where!

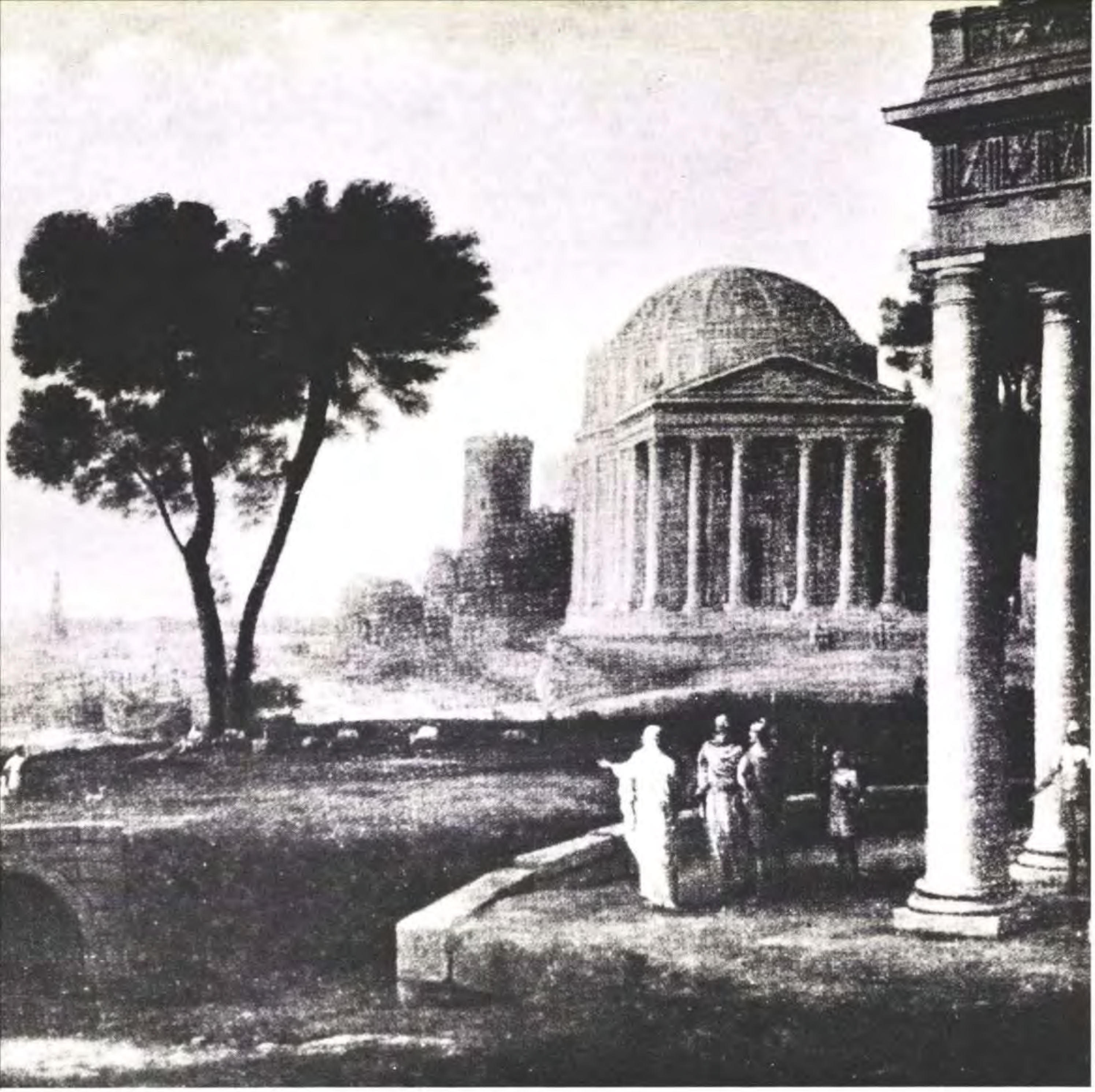


Fig. 7
Utopian Dream – classical landscape

Europe is rich in a marvellous inheritance of buildings and places, a veritable treasure-house of many cultures; the result of both very self-conscious societies, as well as others whose designs are derived from very unself-conscious attitudes, vernacular in tradition. Both have, of course, been of considerable influence on each other. But these places must be treasured. The built environment had qualities then reflecting values that are so manifestly lacking in those that on the whole we build today. Of course, the façades of these glorious towns hid much ill, but they also bestowed great benefits. Those who lived in and built these places clearly had great pride in them, and I submit that this does not happen by accident but only by loving care.

Turning more to today, William Morris, whom I always look back to in some ways as one of the founding fathers of the Modern Movement, remarked, 'Never have anything in your house which you do not know to be useful or believe to be beautiful' – the functional and the aesthetic. Nevertheless, we must remember that the movement was a visionary one, and its leaders were deeply committed to its social aims. (Its aims were in many ways revolutionary, and its architecture indeed perhaps too often a polemic). Yet I believe that in it there were certain inherent assumptions which, for all its visionary momentum, have failed to move its audience and, at worse, alienate it. Amongst these was a romantic view of technology, where there was too little correspondence between word and deed. Functionalism was preached, but aesthetics too often practised.

Dreams

Of course, it is easy to be wise after the event, but we have to distinguish between *dreams* and *aspirations*. The Modern Movement can be much criticized for constructing dreams, whilst the public aspired to something different (Figs. 7–9). Something in their terms more recognizable, rather more simple, less esoteric, more ordinary, but good and welcoming, something to which perhaps they may have to reach up to – for artists must always stretch us – but which they could nevertheless grasp and relate themselves to more readily. In being able to feel more in sympathy with what was being built they could feel more secure, and therefore more able to make it their own. The heroic period of the Modern Movement – the period of the 30's – failed *generally* to provide this quality. There are, of course, splendid exceptions.

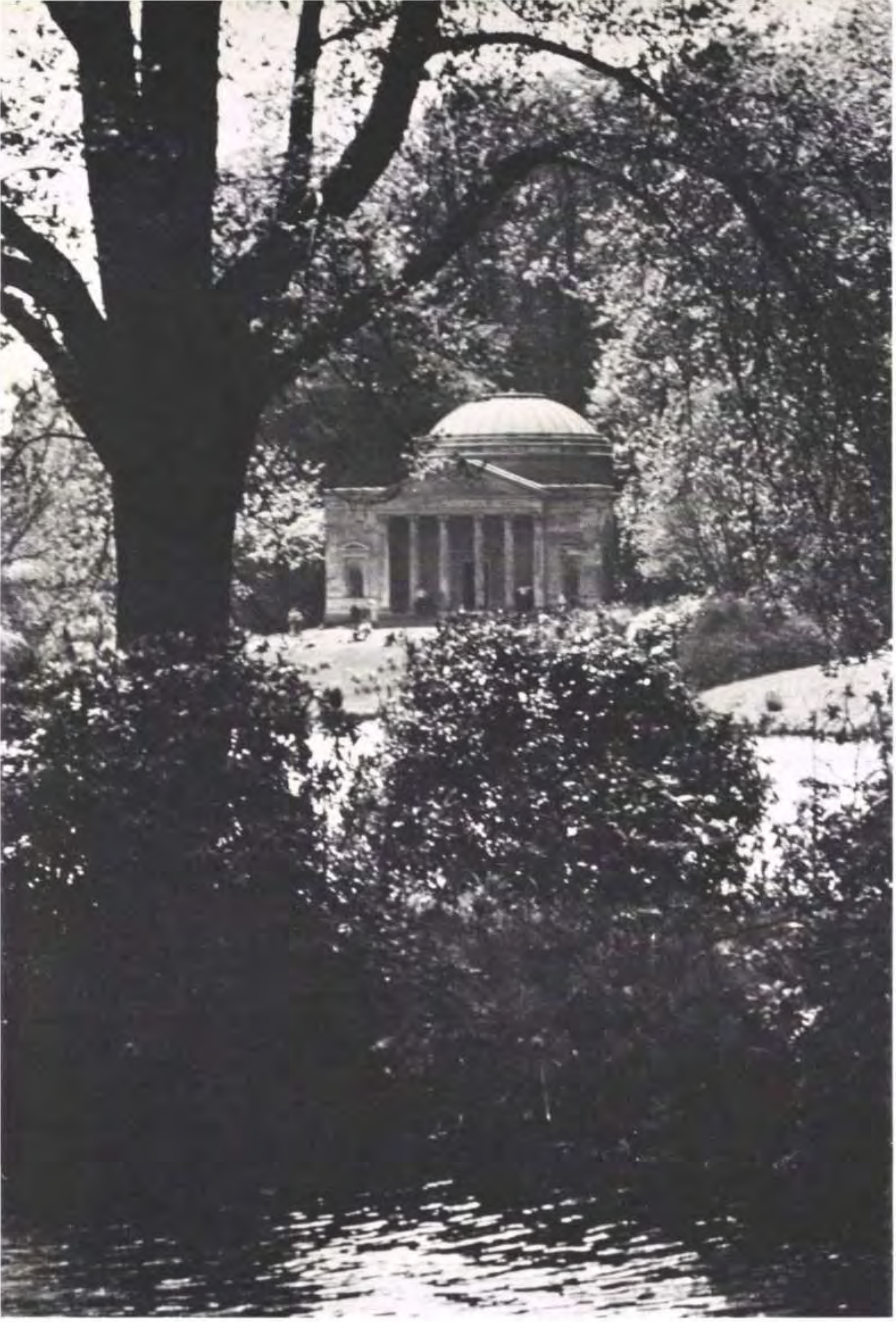


Fig. 8
Utopian Dream – Stourhead

Fig. 9
Dreams? – Roehampton

Fig. 10
In cities too, the buildings have become aloof – beautiful at times, magnificent as well – crystal caverns with a cold embrace.

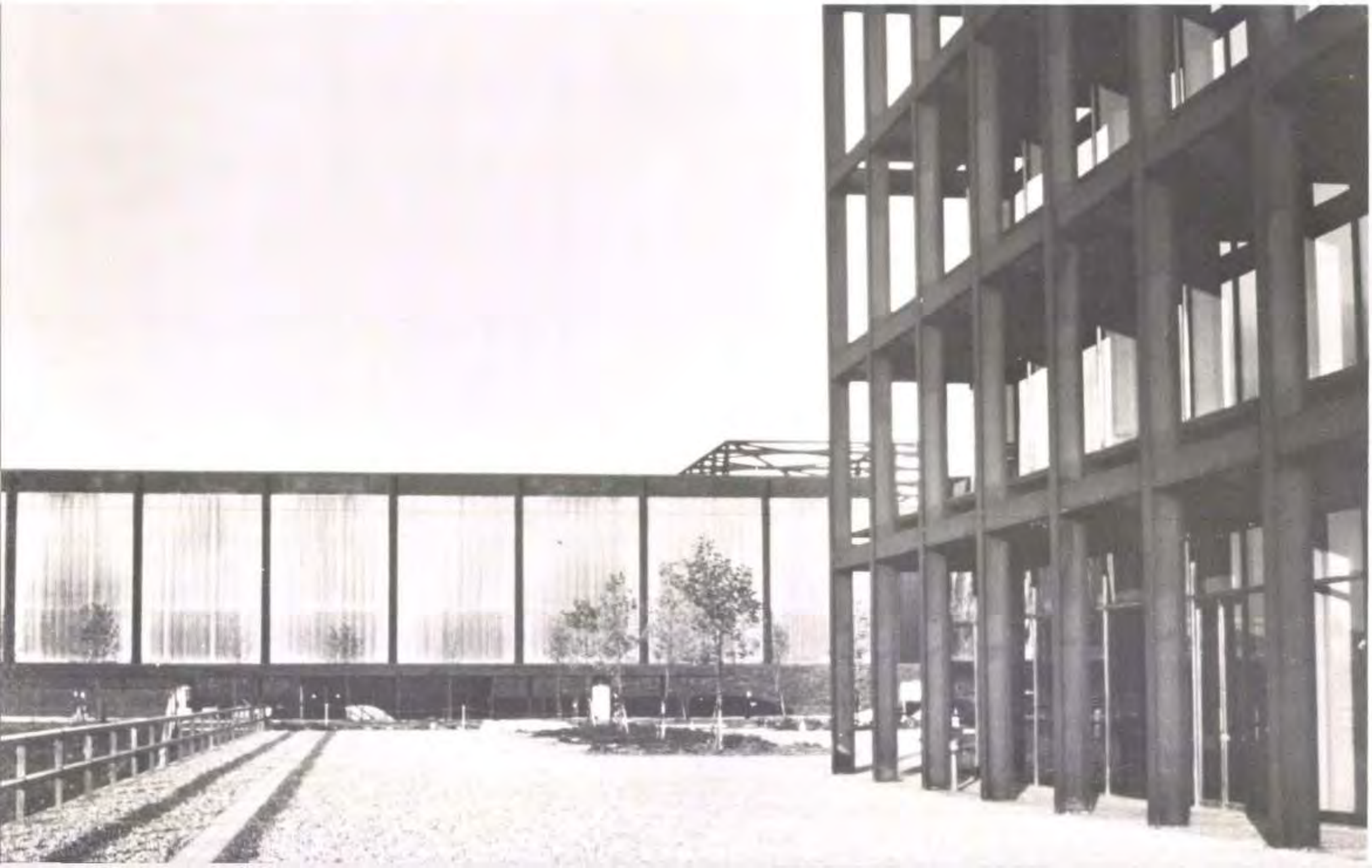
This brings me to a quotation from *Architectural Review* in its leading article in its October 1975 issue on the new Wills Factory at Bristol (Fig. 11) – 'Certainly it is a building which sums up the experience of the middle two quarters of the 20th century . . . It is equally possible to say that it is not "architecture" at all, that it cannot "touch the heart"; and that it symbolises a way of life, of work and of organization, which we are anxious to get away from.'

'A work of architecture is also a work of prophecy, of advertisement. In so far as this job is classifiable as architecture, it is heralding and extolling a "future" which is past – an event which has come and gone and has proved disappointing.'

I believe this sums up very much the position as it is at present – the architectural position that we have arrived at today – so where do we turn?

In observing on some personal convictions I first want to touch on the subjects of conservation and compatibility, with some examples and then, before ending, take a rather more technical glance at a particular development.

Fig. 11
'A future which is past'?
Architectural Review, October 1975



THE NEXT STEP

Conservation

In touching first on the whole vexed question of conservation, I would like to say that firstly in conserving we are learning, and I would predict that this movement – it has already become one – will, and may already, be having a surprising influence on architectural thought and development. It is rare indeed to find an issue on which 'student youth', 'amenity societies', and the 'establishment' should share so much in common – even a bit dangerous perhaps – and the fear now amongst some, is that the bandwagon could already be out of control. A fear that the ideas themselves will be run over and become victims of their own success. That what could be a sobering and thoughtful movement towards a more humane and more sensitively scaled approach to planning and architecture, will become frozen into a dogma of preservation or, worse still perhaps, embalmment, reproduction or historicism. I, personally, do not share this view. I welcome the moment and its challenge. It gives an additional impulse and guide to design. It *adds* to proper limitations, which is never a bad thing, and aids the search for better answers to more real problems. The need to conserve our natural resources, particularly energy, is alone already having a profound effect on the design of buildings.

Conservation, as we are now beginning to realize, is a necessity – we cannot afford to go on destroying our building stock in such a profligate manner – and this is a very political question. However, unless we, in the environmental professions, take a very active role in this field, and give a lead, it would be perfectly reasonable for the public to reflect that they got along very well without separate professions, as we understand them, for a very long time, and who is to say that our predecessors' values, and quality of judgement in the field of the built environment, on the evidence of past results – which they are now trying to protect – are not more than a measure of our own?

South West Regional Headquarters for CEGB
Fig. 12a (above)
Energy conservation

Fig. 12b (right)
Identity of
Small working groups

Fig. 13
The building in landscape

Compatibility

Next the question of compatibility – between ideas – of scale between old and new – between materials and so on. 'Compatible' may be an unfashionable word, smacking of moderation, compromise, of a lack of conviction or of invention. Indeed, at a time of so many conflicts of interest, it can be argued that the idea implied would at best be meaningless, and at worst merely obstructive. However, I personally believe it to be very important in any design approach. It has to do with the appropriateness of a balanced solution. As an example of these two aspects – i.e. conservation and compatibility – I am turning now to something a little more specific and technical both in a conservation sense as applied to energy, and to the design of an office building as a subject.

Just as to start with, a new material will often inherit the forms of an older one, until it is better understood, and a new grammar applicable to the new material is developed, so the form and anatomy and planning of office buildings, with controlled environments, is taking time to be better reflected and absorbed within their designs. And on this score, I hope that the design of the very large modern office building, as at present understood, is reaching towards the end of its course.

The classic example is the wide utopian interior, in which the occupants have contributed *no* part but their *presence*, in a precise and pre-ordained arrangement. The endless, perfectly lit, air-conditioned nightmares – the spacelessness – the clinical perfection of detail aimed at solving technical problems, rather than enriching the place of work, and so the human experience, are too well known to need illustrating. The danger is the anonymity that goes hand in hand with adaptability in some of these interiors; when the accepted priority for adaptability does not recognize the need for individual identity or expression, it becomes a kind of tyranny. I remember walking round an esteemed German example of open office planning (cutting my way through the undergrowth of indoor plants) and coming across a large notice which simply read 'We hate bürolandschaft.'

The design of the new Regional Headquarters Building for the CEGB had all this very much in mind and tried, with them and a representative of the Tavistock Institute, to plan a place of work which will be a community for 1,200 people, and which will take account in its plan, of:

(1) The social and administrative structure of the organization – studied by the CEGB and the Tavistock Institute

(2) The importance of 'identity' to the individual in the physical structure; a structured scale and space to which he can relate at his place of work

(3) The needs of conservation, particularly energy

(4) The compatibility of the design as a whole within a beautiful and sensitive site.

Fig. 14a (above)
Housing at Elsinore by Jørn Utzon

Fig. 14b (left)
Each house has its own private court garden, which is closely related to the communal one

This next is going to be a slight digression and very difficult to try and express – but I will try!

We have, by the organization of the spaces, tried to reflect the social and administrative structure, and exploited the way that spaces can establish a relationship between the small and the large-scale and between the man-made and the natural surroundings.

Nevertheless, however the spaces are organized, they have to be constructed. If the buildings are made, or put together, out of units of an appropriate size and in such a way that the *construction method* itself plays a part in establishing the characteristic of these spaces, then a more articulate architecture can result and establish a stronger sense of place and location: more descriptive, more understandable.

By emphasizing clearly *what* is being done, by *how* it is being done, we can help to illuminate architectural ideas, and so lend weight to the purpose, identity and mood of the buildings themselves.

I have also always felt that the richness and unity that can at once be derived from the diverse use of repetitive elements, and the strands that can be woven within strict disciplines can help to identify the part with the whole, and so help to create a sense of belonging.

This is not the expression of structure for its own sake, so much as accepting the consequence of how it is made which will be implicit in the result. This is an important distinction.

To return to the case of CEGB. By working towards limiting conditions in the conservation of energy, we had to relate the *detail* to the *whole* very directly. For example, by cooling the perforated main slab at night to control the temperature of the interiors during the day, severe restraints were imposed, at one end of the scale, on the planning and sections for the air distribution system to work and, at the other, on the detail of the desk design, because 'task lighting' is necessary in the circumstances to keep heat loads down. The interdependent nature of an integrated system in this case is very apparent.

It is attractive to speculate on the consequences of working towards limiting conditions in this way. The notion of 'limits' could perhaps give a new slant to 'Less is More', and keep us more closely in touch with recognizable answers to real problems.

I would like to finish with two examples of buildings which do not easily fall into any architectural pigeon-hole or category, one small-scale, and one large, and both by the same architect, Jørn Utzon, and both of which for me inspire hope.

First, a housing scheme at Elsinore.

Each house here has its own private court-garden, but closely linked to the communal gardens – now grown up with trees. The photographs (Figs. 14a and b) were taken just after completion in the mid-50's. A simple, straightforward L-shaped house is the basis which, sensitively and variously grouped together, creates a real and compact human environment. It is certainly a very distinguished development, but more than that, it is a place in which one could readily imagine living, and can imagine the possibility for free and happy children growing up within homes that have an individual identity within a larger embracing one.

The second example is the Sydney Opera House.

Every generation (as every individual) has a need to discover itself, if it is to have a *recognizable* identity, and so the self-confidence to act in its own interest. It must put a mirror up to itself and have its symbols, for self-recognition, for self-respect, and to inspire effort. On this point, I should like to dwell for a few moments on the Sydney Opera House itself.

In human terms alone it has been an extraordinary endeavour and achievement, and in the high service of what I believe to be largely an imaginative and symbolic idea. Of course, it provides for many other things as well, and has to fulfil many other purposes. But for all its functional aspects and its technical brilliance, it is finally and most importantly a symbol and a work of art. It is having an influence not only in Sydney, but in Australia as a whole, and at a number of levels which are very profound indeed; and which perhaps people are only just beginning to be aware of. They are discovering in its presence things which are important to them, and that have to do with values. It has changed their view, just a little bit only, maybe, but it has enriched it.

I believe it is a great building. A kind of marvellous Trafalgar Square on water, full of life and activity; which, anchored in the harbour at the very focus point of the city, commands a presence without entirely dominating it which is unmatched in any other city that I know of. Taxi drivers will also tell you that it is very beautiful, and I believe they are right. There must always be a place for the splendid architectural gesture of this kind, provided, of course, that it is splendid, but these will always be very few and hazardous. They are perhaps an impudence to the gods, whose retribution will almost certainly be visited sooner or later on those involved – on those who would aspire to fly so high!

I, personally, just marvel at how this wonderful architectural rogue elephant managed to find, or blunder, or stampede its way through today's tightly woven mesh of anti-patronage. The very word 'patronage' is almost a provocation, and yet enlightened patronage we must have, if we are to have fine architecture at all. Patrons who, in making great demands, must also be prepared to take great risks.

In concluding, I would make two pleas – one to do with means and the other with ends. On the first, I must assume I am preaching here to the converted. Certainly a closer understanding and integration between the professions is essential, particularly in Government and Local Government, where some of the most archaic and rigid professional divisions still exist, originating from the traditional departments with their own separate career structures. This segregation, I believe, can too readily result in a destructive and artificial division of what are closely associated activities, and which must greatly contribute to the discord in so many developments that afflict our cities, towns, and much of our countryside – monuments to isolated thinking. As Casson has remarked, 'If architecture is frozen music, then this is frozen noise'.

Second, we have seen heralded since the war a number of architectural movements – the New Empiricists, the New Brutalists, the Metabolists, and so on.

I would *plead* for a return to a *new architecture of humanism* – that is what we are here for – all of us who are involved in the design of our surroundings; to create circumstances in which the various designers will be in a better position to deal with our very complex situations, whether he is a traffic engineer, whose problem can be as much social as technical, or an HVAC engineer, whose concern must be controlled environments sensitive to human responses. We must continually remind ourselves that the purpose must be to try to develop methods that can compete with the pressures of scale and technology, and to revalue them in *human* terms. We have to try and produce an architecture that is human and not brutalizing and, whilst obviously embodying as fully as possible the 'technical', will not continue to do so at such great social expense.

We have an obligation, a Hippocratic Oath if you like, to be sensitive in using our resources for human purposes, and not to attack our environment but to conserve it, to be used and to be enjoyed. And to this end, we have to co-ordinate our activities in today's climate of technical proliferation, if we are to secure the realization and the survival of humane ideas.

People, on the whole, ask us for rather simple things, and they ask for them in simple language. They want their houses to be homely. They ask, with increasing anger now, why architects don't build 'beautiful buildings' – these words we avoid at our peril. They are a cry for very human and ordinary things; for places to live in, or work in, that people can respond to and enjoy, and this means that they must be understandable in ordinary human terms. That is not to patronize, but to respect.

I would like to close with a quotation from Walter Gropius, who was one of the real fathers of the Modern Movement, and this was said many, many years ago, 'We must recover a comprehensive vision of the wholeness of the environment in which we live. In our mechanized society we should passionately emphasize that we are still a world of men, and that man in his natural environment must be the focus of all planning'.

The next step is not a new step, perhaps, at all, but an old one that we have yet better to understand.

Fig. 15
Sydney Opera House
A symbol – which works on many levels

Scottish Opera, Theatre Royal, Hope Street, Glasgow

Richard Frewer

The first 'Theatre Royal' was designed by the Glasgow architect, Mr George Bell. It was called Bayliss's Coliseum Theatre and Opera House and was opened on Thursday, 28 November 1867. The opening night was the production of a sensational drama called *The sea of ice or the gold seeker of Mexico*, prices of admission being from sixpence to two shillings and sixpence. The first opera performance was given on Monday, 9 December 1867, with a production of Verdi's *Il Trovatore* by Madame Florence Lancia's Grand English Opera Company.

The name was changed to the Theatre Royal in May 1869 when Messrs Glover and Francis acquired the lease. Under their new management, the theatre opened with a performance of Offenbach's *Grand Duchess* on 8 June 1869.

On 2 February 1879, the theatre was totally destroyed by fire and was rebuilt to the design of the London architect, Charles John Phipps, who was responsible for the design of more than 30 well-known London theatres and provincial opera houses, including Her Majesty's in the Haymarket, London, the Theatre Royal, Brighton, and the Lyceum, Edinburgh. In 1891, he became involved in a serious professional dispute with T. F. Knightley over the authorship of the design for the famous Queen's Hall, London, built in 1891 and destroyed in the Second World War. For 15 years, he was consultant architect to the Drury Lane Theatre and was consulted by committees of the House of Commons and colonial governments on questions of theatre construction and acoustics.

The new theatre was opened on 26 October 1880 under the management of Miss Marie Litton, otherwise Mrs W. Robertson, with a performance of *As You Like It*. On 7 February 1881, Miss Litton started a series of promenade concerts of which Signor Foli and Signor Runcio were amongst the singers who appeared on the opening night.

There were different managers from 1881 and it was closed for some long periods until Messrs Howard & Wyndham Ltd. took possession in July 1888. The theatre was reopened on 10 September 1888 with Mr Henry Irving and the Lyceum Company in *Faust*.

On 1 March 1895, the Theatre Royal was again destroyed by fire. The architect for the reconstruction was again Charles John Phipps and the theatre was reopened on 9 September 1895.

In 1924, the directors of Messrs Howard & Wyndham Ltd. carried out improvements to the Theatre Royal and in the *Evening Citizen* of 5 April 1924, a short article recalls the history of the 'Royal'.

The theatre was sold to Scottish Television in October 1956.

Our first contact with Scottish Opera was a letter from Peter Hemmings, the General Administrator, in August 1972. This asked Arups to give their view about the possibility of renovating the theatre which, at that stage, was a makeshift studio and administration building for Scottish Television.

After inspecting the building and deciding that the possibilities were worth pursuing, the Opera Company had to be convinced that the cost, which was much greater than they had expected, could be met and that the money was worth spending.

After cost studies and early design work on the stage, pit and seating, we were appointed in January 1974 to prepare designs with a view to opening the opera house in October 1975. Design work started in April 1974 and the scheme design report was presented in August. The contract was to start on 1 October 1974 with completion on 30 September 1975.

Scottish Opera had asked us to provide them with a home; a fully equipped opera house which was also suitable for ballet and theatre. We were to house 100 artists and form a pit big enough to hold a Wagner orchestra. It was hoped that at a later date the whole company, including its administration, could be housed in the opera house. The auditorium was to seat between 1500 and 1600 people.

Fig. 1
Henry Irving in characteristic pose – as Wolsey in *Henry VIII*
(Photo: Courtesy of Mary Evans Picture Library)

Design references

For design work on the Theatre Royal, Glasgow, the major references were not books and plans, but the existing theatres at Brighton, Edinburgh and, of course, Her Majesty's in the Haymarket. From the study of these buildings, the atmosphere of the Theatre Royal and the Phipps' design approach were reconstructed. At no stage was it considered that a faithful reconstruction of his design was being made. The layout of the Theatre Royal, Glasgow, separated strongly the social classes and the different entrances were clearly segregated. What was astonishing was the discovery that although the top tier in the theatre is very sheer, it is said that originally there was yet another one on top. The theatre is now only ably to accommodate just over 1500 people – in the 1890s, 4000 were crowded in. The theatre was not over-endowed with lavatories and the ventilation was very primitive. Conditions must have been appalling by present-day standards.

Tradition of Victorian theatre

By the second half of the 19th century Glasgow had become one of the major trading centres of Europe, and as such it developed a great theatrical tradition. The music hall, theatre and opera were enormously popular.

The style of the period was paper-thin, theatrical for its own sake, a style in which classical forms were misused to satisfy self-indulgent flights of fancy. The late Victorian eclectic style was a contemporary 'pop' style; an age of glamour, glitter and frippery, which of course had the most vulgar and debased aspects as well as some of the finest.

The greatest single influence on Victorian theatre decoration was the Paris Opera, designed by the 25-year-old Charles Garnier (Fig. 3) and the introduction by him of the red interior. In those days, this was considered the ultimate in plushyness. However, any style was used and on theatre buildings the decoration tended to be added as a paper-thin aesthetic on a 'sound' structure: 'Shall we have instant Tudorbethan, Chinoise or French Renaissance'; you name it, they had it. It was 'a creative pastiche'. Their use of the classic idiom would have made Vitruvius turn in his grave, but the buildings had spirit.

As far as the mechanics of performance are concerned, to produce the spectacular, the Victorians developed highly sophisticated

Fig. 2
Trongate, Glasgow, in the 1880's
(Illustration: Courtesy of Mary Evans Picture Library)

Fig. 3
The foyer of the Paris Opera House
(Photo: Keystone Press Agency Ltd.)

Fig. 5
West façade of Glasgow School of Art
(Photo: Annan Photographer, Glasgow)

Fig. 4
The AEG Turbine Factory, Berlin
(Photo: Firmenarchiv)

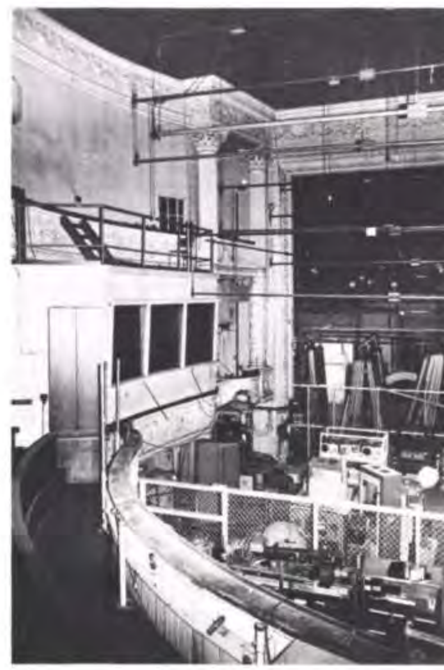


Fig. 6
The auditorium interior
before conversion

mechanical devices for the stage. Revolves, traps, flying mechanisms all existed and, although machinery has become more sophisticated, most devices now used were existing in the 1880s. The only major developments since then have been electrical.

To keep the right historical perspective on the Theatre Royal, this type of theatre, never highly ornate, has as great an affinity to the Odeon style as to 'French late baroque' which was its stylish label. 1895 is only some 12 years before the establishment of the Werkbund in 1907 and only 14 years before Peter Behrens designed the AEG Turbine Factory in 1909 (Fig. 4) with both Mies van de Rohe and Gropius in his office. Charles Rennie Mackintosh (Glasgow Art School 1898–99) (Fig. 5) was practising in Glasgow and Stravinsky composed *The Firebird* for Diaghilev 15 years later in 1910.

The challenge

Arup Associates were asked to provide a home for the Scottish Opera Company from a shell which had been used for the past 15 years as a television studio. The whole theatre had been fitted with a conglomeration of spaces, totally unrelated to its original use. The only area which had survived with any of its former splendour was the auditorium where the fibrous plaster, by some miracle, was left more or less intact and had sufficient of its original style to be the basis of a restoration or rather a design in style (Fig. 6). When design work started we had only 18 months to complete, with the finishing date fixed as 15 October 1975. To have any chance of completing on time a year on site was essential, and we were working with a tight budget in the worst inflationary conditions in our history.

The design approach

Two possible approaches were examined:

(1) Restore the auditorium and redesign the adjacent areas to be in style so that the whole place had a unity and clarity related to the original. This is similar in approach to the musician who completes or realizes another composer's work.

(2) Restore the auditorium and design all other areas as a modern building so that the centre was held like a rich jewel in a highly disciplined contrasting framework.

It was decided that the first approach was the only one in the short time that was allowed. It was impossible to know what the construction would reveal when everything was opened up (as the building was in use by Scottish Television until after a start was made on site). To produce a modern design with any clarity needs a framework with a clear structure. It was known that as the theatre had been changed so much over the years, it would be impossible to achieve this without a greater time scale and much more money than was available.

Using the existing framework, it was possible to give back to the theatre a sense of style by the way in which the existing structure was remodelled, and the way in which the finishes were matched. Having made this decision and tested it with pilot schemes for the services and space planning, it had to be trusted that the rest would follow. We were in the position of having to trust our intuition and stand by it.

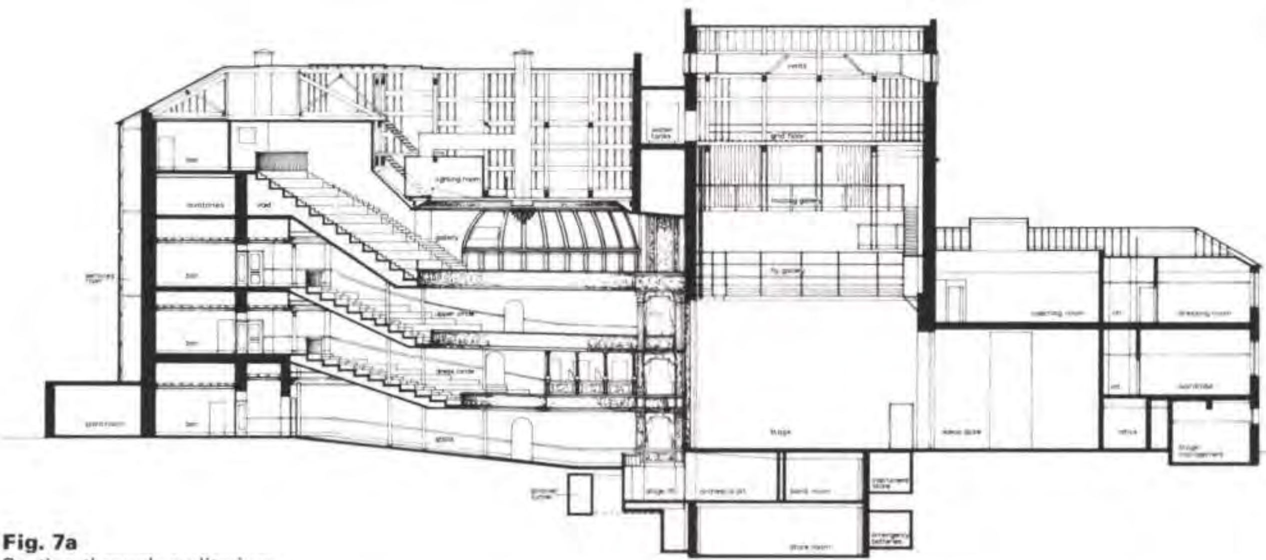


Fig. 7a
Section through auditorium

Fig. 7b
Sub-basement and basement plans

Tactical design decisions

(a) The auditorium design was studied and expanded in style.

(b) Front of house areas (i.e. bars, foyers, staircases) were to be realized as an extension of the auditorium aesthetic.

(c) Dressing room and working areas were to be designed in a simple way which would make it consistent with the rest.

Approach fixed, the rest must follow

Having produced a vision of what was to be achieved, the greatest problem was to hold that picture intact while making quite radical changes at a late date in the building programme. The problem was once described as 'trying to hold a half-set jelly in one piece through a year of very bad weather'. However, the original design by Phipps proved to be rigorous enough to set out a very logical set of design decisions which were followed right through to the colour schemes.

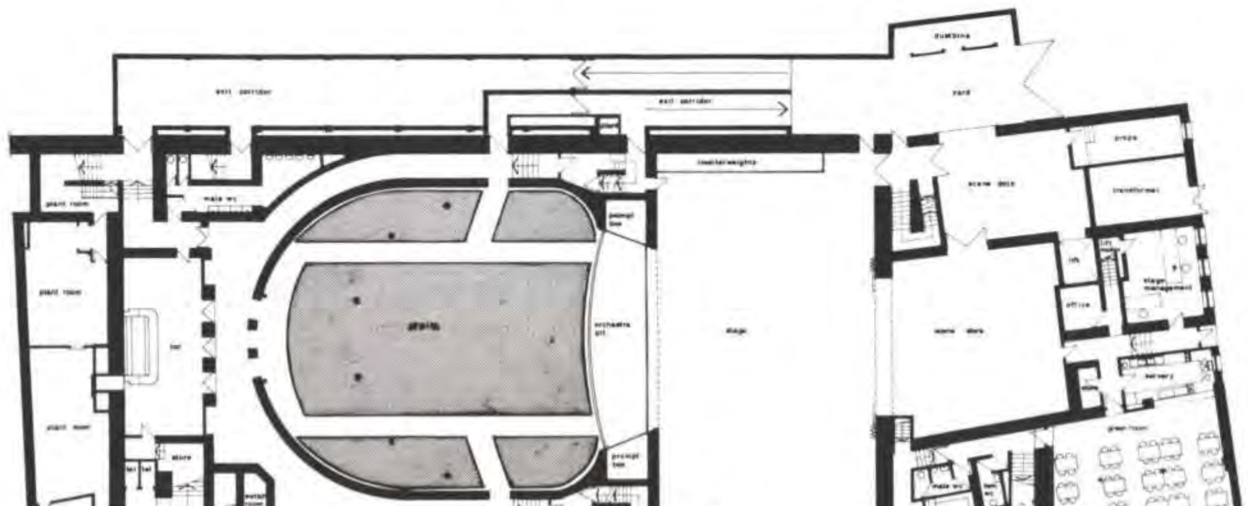


Fig. 7c
Ground floor plan

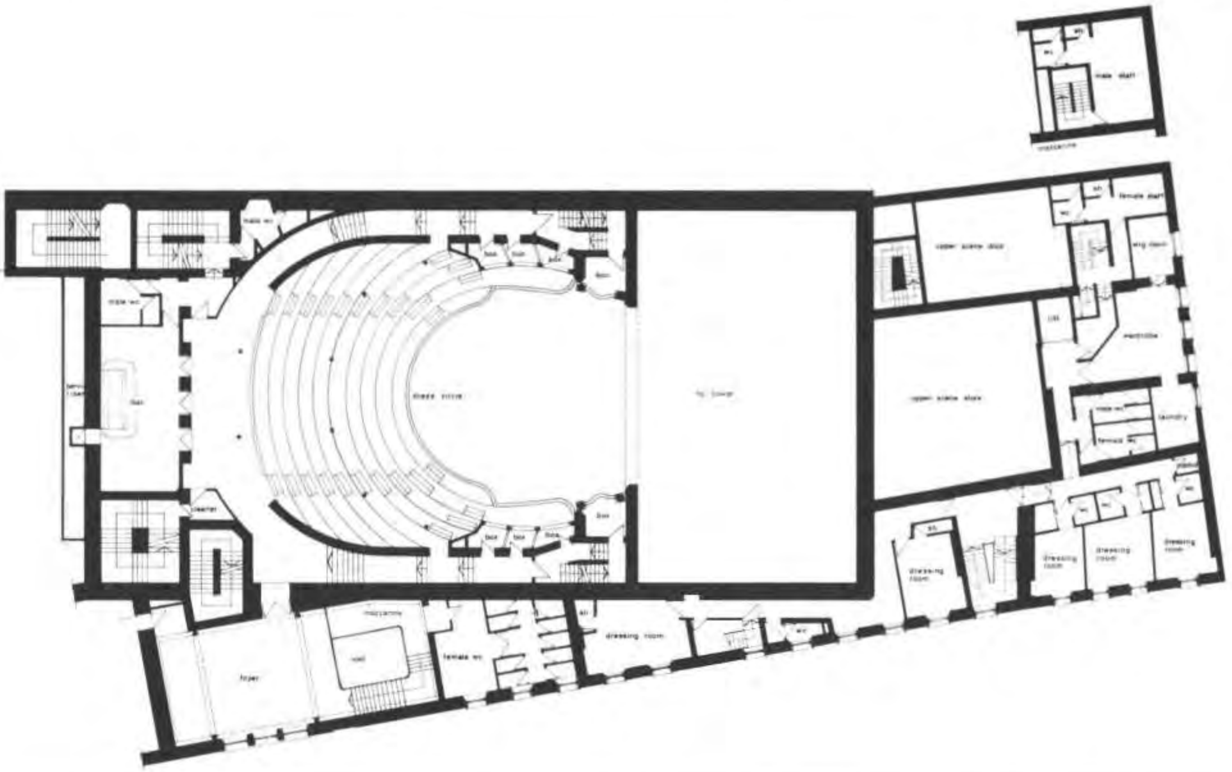


Fig. 7d
1st tier plan

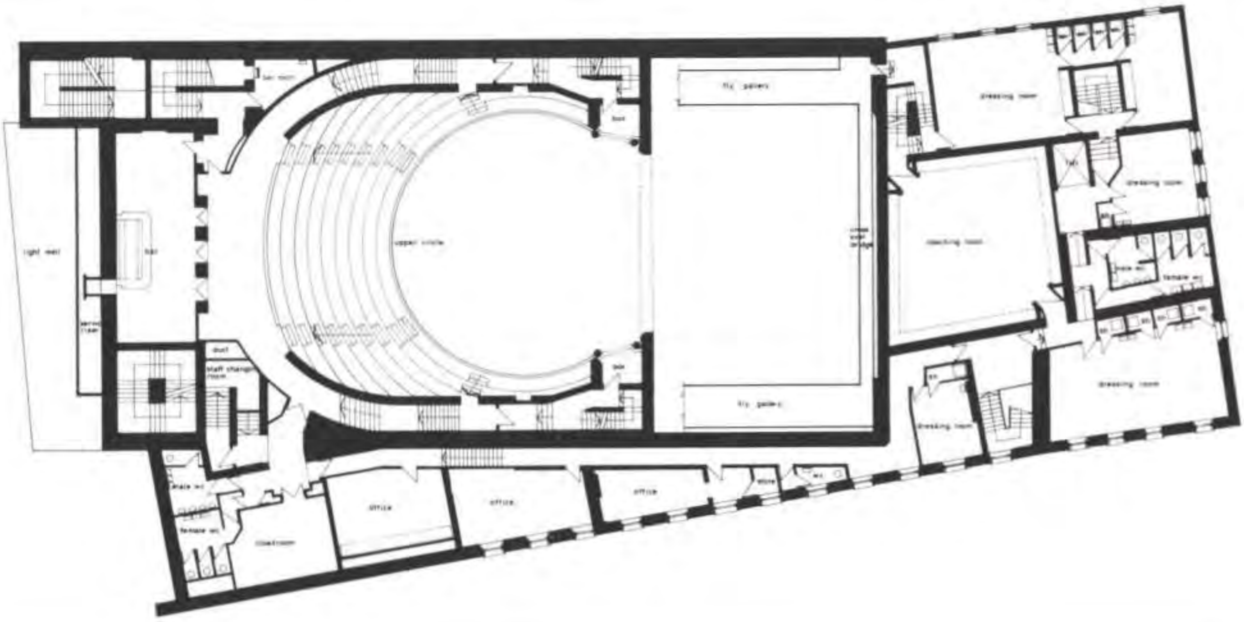


Fig. 7e
2nd tier plan

Fig. 7f
3rd tier plan

Fig. 8
Detail of joinery in the foyer

Use of the traditional crafts

Much of the work, which was involved, relied on traditional crafts. In 1895 much of the fibrous plaster work, joinery, metalwork and wallpaper could be factory-produced and the architects would have been able to choose their patterns directly from the book. Of course, most of their tradition has now stopped and so the designers were in the position of going right back to earlier craft methods to produce their effect. Fibrous plaster moulds had to be especially made, by one of the few master plasterers left in Scotland. Joinery, which was all in mahogany for the front of house, was redesigned using the old pattern books of mouldings and the colour carefully matched to achieve the Victorian French-polished richness. A consistent use of brass ironmongery required specials to be made. Cast-iron rails were modified and redesigned to be recast in aluminium, and the wallpapers were modified from existing ranges to get nearer to the reality. These details are the ones which make the place and give the tactile quality so much a part of a Victorian interior (Figs. 8 and 9).

Building anatomy related to the services

The aspect which has most destroyed the atmosphere of the Victorian theatre is the insensitive intrusion of modern techniques into stylish public areas. In many Victorian theatres, modern peppermint light fittings or even neon tubes now fight with cluster lights on the tier fronts. Outsized biscuit tins house gigantic spot lights over the decorated balcony fronts and miles of wiring, ducting and piping festoon the ceilings. We were determined that these services would be installed within the disciplines of the interior. (Figs. 8 and 9).

Four specific solutions are pointed out to illustrate the approach:

(1) All lighting for the stage, which is usually hung from tier fronts, was placed in the dome or in the slips. This dome was modified to be a plaster-covered trap door which, during the intervals, is closed, giving the illusion of an undisturbed Victorian painted ceiling. (See Fig. 10.)

(2) The follow spots, which are large, cumbersome and unsightly, are built into the springing of the dome. This has the effect of improving, rather than detracting from, the interior. (See Fig. 11.)

(3) All air vents, which relate to ducts behind plastered and moulded false ceilings, are hidden behind the old device of a large cornice used in its correct classical context. This device also improves rather than detracts from the interior.

(4) All soffit lights in the auditorium are recessed in a dark ceiling giving not a sense of disturbance but adding to the intimacy of the space. (See Fig. 12.)

We have attempted to turn items which are usually unsightly intrusions into architectural bonuses.

Fig. 9
The bar. All the woodwork visible is completely new, but copied from Victorian patterns

Fig. 10
Interior of the dome, showing trap doors concealing lighting for the stage

Fig. 11
Auditorium interior, showing follow spots

Fig. 12
The 1st tier, showing soffit lights and the fibrous plaster profiles which mark the air distribution outlets

Sequence of spaces and their changing moods

Theatre is an art of illusion and when a theatre is visited a sense of excitement is expected. The Victorians also expected the illusion of grandeur from the building.

The sequence of space which is experienced as a theatre is entered should prepare you and acclimatize you to the idea of watching the stage.

The pavement outside the theatre entrance should welcome you, give a sense of arrival, and be the first semi-formal space for meeting friends. The north end of Hope Street, where the theatre stands, has little charm. A traditional canopy, which has yet to be erected, will add enormously to the presence of the theatre and prepare for an entrance to the foyer.

Few people who visit the theatre realize that the foyer is totally new. It is remoulded with its staircases and mezzanines within the envelope of the building and is much smaller than we had originally planned. The Opera Company tried to purchase the adjacent public house – failed to do so and we found ourselves without a foyer two weeks before starting work on site.

The total usable area for the foyer and staircase was only approximately 7 m × 15 m, very small and, when first considered, thought to be quite unacceptable. As it was worked upon, it was realized that the Victorians often gave themselves an identical problem. By the use of grand architectural devices in a small space, a strange mix can be achieved which is particularly Victorian. A formal, classical space was constructed with a large chandelier in the centre using mirrors at high level. These give the impression of space and continuity. The staircase with its mezzanine gives views at high level of the foyer below and the dress circle foyer above. The fact that there is a crush in the space and people are seen moving up and down the staircase acts to heighten the excitement and feeling of occasion as the theatre is entered. There is a feeling of grandeur. In reality, the space is only about one-third of its apparent size. The colour is neutral and the lighting is crisp and bright (given by three chandeliers which we found in Glasgow and whose owners were persuaded to give them to Scottish Opera).

The hardness of materials, the neutrality of the colour and the formal mood were chosen to give the audience a clean and neutral reference point, after the streets of Glasgow, before entering the richness of the interior.

On leaving the foyer, a contrast is experienced. The staircases which lead from foyer to the top two tiers are carpeted, papered and lit in the same way as the auditorium. Consequently, they are quiet, warm and inviting. When entering the horseshoe corridors of the auditorium from the stalls or dress circle foyer, the experience, it is hoped, is one of expectancy, mystery and to some extent nostalgia. The colour is dark leather brown, offset with gold on the wallpaper which varies in effect according to the way it is lit. The tactile quality is soft and the people, pictures and mirrors, become the only focus in the area.

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Fig. 13
The foyer – before conversion
(Photo: Eric Thorburn, Photographer)

14

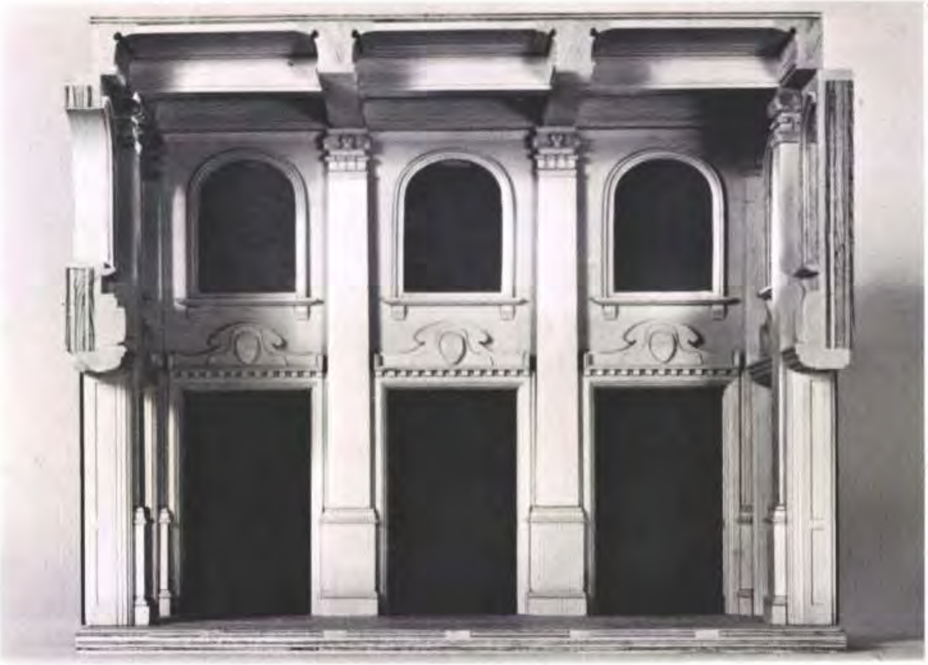


Fig. 14
Model of the new foyer

Fig. 15
The new foyer

15

16

17

18

Fig. 16
The new foyer

Fig. 17
Balustrade detail from the foyer staircase

Fig. 18
Artists' dressing room

Fig. 19
View of the auditorium interior

19

As the velvet seating is passed, one becomes aware of the only bright focus in the auditorium – the front of the tiers. When the centre is reached, the inner crust is entered; this is like a roofed arena. The tier fronts, boxes and proscenium arch, which form the crust, are decorated plaster, painted in a range of creams, touched with gold and lit with brackets set onto the fronts; a deep orange velvet finishes the tops. The dome is set as a contrast in a blue with the decoration picked up like strap work floating in a sky.

As the lights are dimmed and the audience quietens, the eye is focused on the thick dark brown velvet curtain, lightened with gold decoration and lit from the auditorium with a red colour which is picked up in the depth of the pile. The curtain opens, and all being well, the illusion is complete.

Back-stage areas

Although the floor area of the building was only slightly changed by small infill additions, the circulation backstage had to be completely redefined and the rooms rebuilt. Levels had to be tied together in a logical way and the whole area had to be provided with washing facilities for 100 artists. The idea of hiding all the services was out of the question, so simple rules were made which would allow services to be put in. A cornice was applied about 2 ft below the ceiling. The exposed services were run above the cornice and the ceiling and services were painted a dark colour. Below the cornice everything possible was done to eliminate evidence of these services.

Lavatories were given another set of simple rules and furniture was made to fit the visual grammar that resulted. By this means, the sub-contractors who started in this area of the building could proceed with little information – not an ideal situation but one forced on us by the speed with which the work was carried out.

Future possibilities

Scottish Opera have already formulated plans to add to the building. A canopy is to be added to the outside along Hope Street. A dome is to be added to the existing entrance tower to give a larger gallery bar, and a large bar which was once part of the theatre is to be re-used. But there are problems at present with each of these. Even longer-term projects are being discussed. All of them are possible but at present we must wait.

The first season

Scottish Opera's first winter season has now finished and the percentage capacity audience speaks already for the success of the project. 85 to 90 per cent average capacity of the 1500-seat audience has been filled throughout the season. This must add even more to the very high reputation of Scottish Opera.

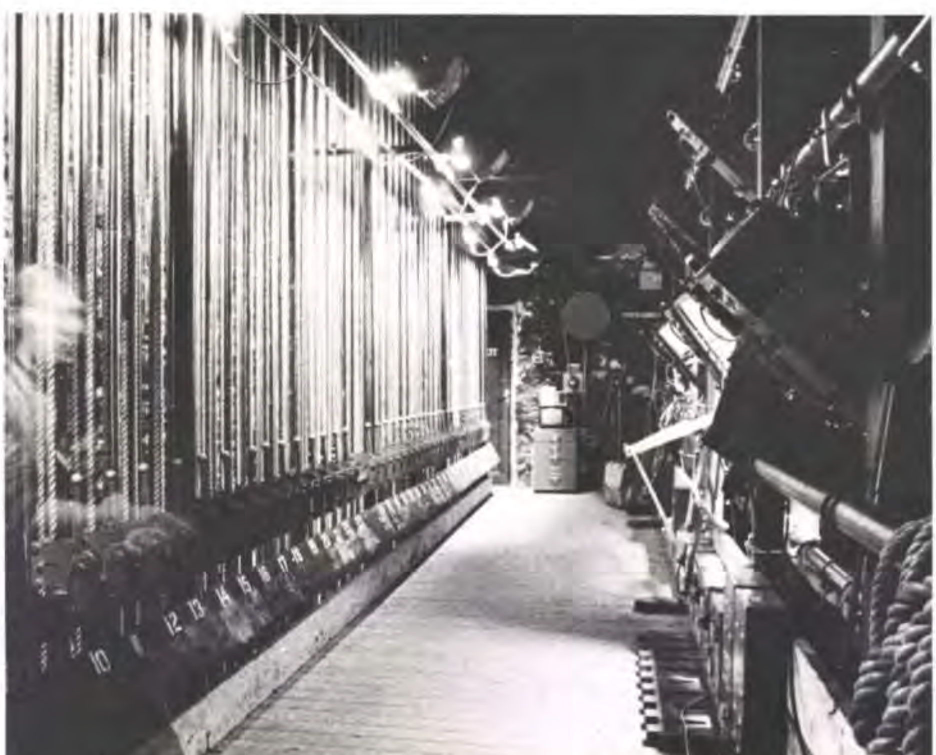


Fig. 20
View of the auditorium interior

Fig. 21
Stage pulley systems
seen from the fly gallery

Ventilation and heating

Modern standards of heating and ventilating were required without unsightly intrusion on the Victorian interior of the theatre. An inspection of the Theatre Royal in Glasgow and in Brighton showed that Phipps incorporated natural ventilation in his auditorium design and the theatres were heated by coal fires. His method of ventilation for the auditorium was to have openable windows at stalls level to let fresh air in, and openable windows at the back of all bars with 'chimneys' at the top of the gallery and dome to draw the hot air out (the ventilation took with it any heat gains from lighting); this idea was taken in the new design and adapted. Outside air is brought in free of cold draughts and traffic noise, through low pressure nozzles at all levels of the auditorium as close as possible to the occupants. This provides steady air movement without noise generation. Mechanical refrigeration cooling was not considered necessary as opera has a winter season when free, cool, outside air is available.

It was essential in the planning to ensure that the location of plant prevented any noise problems in the auditorium as this had to be very quiet (noise rating of 20). The boiler plant and auditorium supply fan were located on rock at stalls level behind the stalls bar. The exhaust from the auditorium was achieved naturally by stack effect without the use of fans. The timber roof trusses had an unknown natural frequency with the possibility of sympathetic vibration from any fans. This could have caused unpredictable noise. The design of these exhausts was complicated as they had to satisfy all the requirements of acoustic separation, smoke release and volume control. Interlocks with the smoke detection system ensured that if smoke were produced anywhere in the auditorium, stage or orchestra pit, it would not be circulated by the ventilation plant to other areas.

Gas was selected as the primary fuel as it is quiet in operation and requires minimum space. The boilers chosen have atmospheric burners and as the boiler plant room was long and thin, an 11-module plant was selected. This plant had the added advantage of low thermal capacity to respond rapidly to the peaky load profile of the main auditorium supply plant and the hot water supply. The hot water supply had special gauges for monitoring of flow rate and consumption of hot water, as the HWS load may peak at 120 showers in 20 minutes. As this peaks occurs infrequently, the boilers were not oversized. However, when the flow rate approaches this peak demand, unnecessary plant is switched off to dedicate the whole boiler plant to hot water supply.

To handle the special problems of heating a stage, radiant panels were provided under the fly galleries and fan convectors were fixed on the rear wall of the fly tower to warm up the large volume of cold air so that cold down draughts are minimized when the curtain first rises.

Electrical services

The electrical installation in an opera house is extremely sophisticated and covers every aspect of modern practice. There was an added problem at the Theatre Royal; the system had to be fitted unobtrusively into a Victorian interior.

The building has all the electrical systems associated with a public building. Lighting, emergency lighting, power, fire alarms, lifts, telephones, etc., are all needed, as well as those services associated with a fully equipped opera house stage. There is a 1200 ampère supply to the building, of which some 800 ampères are taken by the stage lighting.

The equipment includes:

(1) A total of approximately 700 lighting outlets throughout the building linked to the stage from the dome and the flies.

(2) A bank of 240 controlled dimmer channels with the equipment sited under the stalls level.

(3) Power for stage equipment. This includes two stage lifts, a lighting bridge and a 4.5 tonne safety curtain.

(4) Theatre sound system (sound effects and amplification).

(5) Wiring for outside radio broadcasting.

(6) Stage manager's sound system.

The stage manager's sound system controls the whole 'operation'. Artists can be paged from any part of the rear of the house to the stage and they can be cued both visually and verbally, and public announcements can be made. In addition to this, special effects, scene changes, off-stage musicians are all monitored from the one mobile stage manager's desk in the corner of the stage.

To give an idea of the money needed to run the electrical installation, each show costs approximately £35.

The contract

It was clear from the beginning that to meet the very tight programme (even without the delays that occurred later) the early appointment of the contractor was essential. The most difficult part of the work to assess was the change needed to the structure and fabric of the building. Any contract which attempted to define these in detail would have been impracticable. The 'inspired' guess of a year on site needed to be proven and related to the work content. The contract needed to be flexible to reflect the inevitable changes in a project of this type, as there was no time for haggling in mid-contract. We wanted a contractor who was experienced in this kind of work, had initiative, was forward-looking and with a streak of madness to match our own.

A management contract seemed the obvious way to deal with the early appointment and flexibility. But we had reservations about whether this kind of work could be approached from the 'distance' of a management contractor. Sir Robert McAlpine Project Management Ltd were appointed four months before site operations began.

In the event, everything except the most tricky structural operation was sub-contracted under the control of the management contract. The execution of the work in the last three months disproved all the principles of programming and the cash flow predictions, and the term 'out of sequence working' became a familiar phrase at site meetings in the scramble at the end.

The standard of programme information is critical to the success of the project. This requires a high level of expertise from both the contractor and the architect. Secondly, the standard of cost control and its monitoring related to the programme can not be overstressed. Any weakness in these aspects must be vigorously remedied.

The fact that the job was finished on time was largely due to the tremendous commitment of all the parties involved and the excitement generated on site. The conditions under which people were prepared to work speaks for their enthusiasm, and the fact that some traders were working around the clock at the end of the job shows the pride that everyone had for the new Scottish Opera House.

Credits

Architects, Engineers, Quantity Surveyors and Acoustical Consultants:
Arup Associates

Client:
Scottish Opera
Theatre Royal Ltd.

Theatre consultants:
John Wyckham Associates

Management contractor:
Sir Robert McAlpine Project Management Ltd.

Photos: Arup Associates,
except where otherwise stated

In pursuit of abandoned mine shafts

Josephine Challinor
John Henry
Richard Hughes
Carl Poster

4,000 years of mining in the United Kingdom has left a substantial legacy of derelict land. This land amounts to tens of thousands of hectares and frequently lies in the path of expanding cities. Finding the mine shafts and workings poses a formidable problem for successful land reclamation. The hazards of abandoned mine shafts have been illustrated by the unexpected appearance of gaping holes, up to 15 m in diameter, beneath or near structures. These sudden collapses are mainly due to the casual method of backfilling shafts which was used before regulations on abandonment came into force.

Most past mining has been for coal, in South Wales, the Midlands and the north of England, but over 20 other minerals have been mined throughout the United Kingdom. Each mine, at its simplest, may have had only one shaft for access, but often there were several shafts serving different functions associated with a mine. Considering the variety of sites and problems, it is clear that there cannot be a standard procedure of investigation for land made derelict through mining. There are usually only two general elements common to all investigations. They should commence with a thorough search for, and examination of, all available maps and documents related to the mining activity of the site. The investigations should end with either excavation or drilling to positively identify the suspected shafts. With luck, these steps may comprise the whole effort. However, for poorly documented or for very large areas, it may prove necessary to include other methods which can delineate the most likely areas for shafts or workings.

Methods

These methods attempt to detect, from the surface or the air, disturbed areas below ground which may be associated with mining. The methods which have been tried range in sophistication of instrumentation from divining with forked sticks to surveying with ground-penetrating radar. Divining, which is widely used for this and similar problems, is unsubstantiated by controlled tests. Ground-penetrating radar is one of many geophysical techniques which have been adapted for purposes of detection.

Initially, geophysical methods might seem to play a useful role in finding concealed shafts. Two common geophysical instruments, the earth resistivity meter and the magnetometer, enable rapid examination of a site for anomalies in the electrical character of the ground or in the magnetic field at the surface, respectively. These anomalies may arise because an abandoned shaft is filled with air (a poor electrical conductor relative to soil) or metallic debris or other magnetic material such as cinders. Several other more elaborate methods are feasible in some circumstances. Instruments which measure changes in the acceleration of gravity are sensitive enough to detect the mass deficiencies below ground caused by some air-filled or even loosely back-filled shafts. Also, seismic systems can detect shafts through changes in the character of sound waves in the ground.

All these methods and others, including ground-penetrating radar, have been used with

Fig. 1
Aerial photography, 12 March 1972, 1610 hours. Approximate scale, 1 :10,000

Fig. 2
Aerial photography, 6 June 1973, 1215 hours. Approximate scale, 1 :10,000

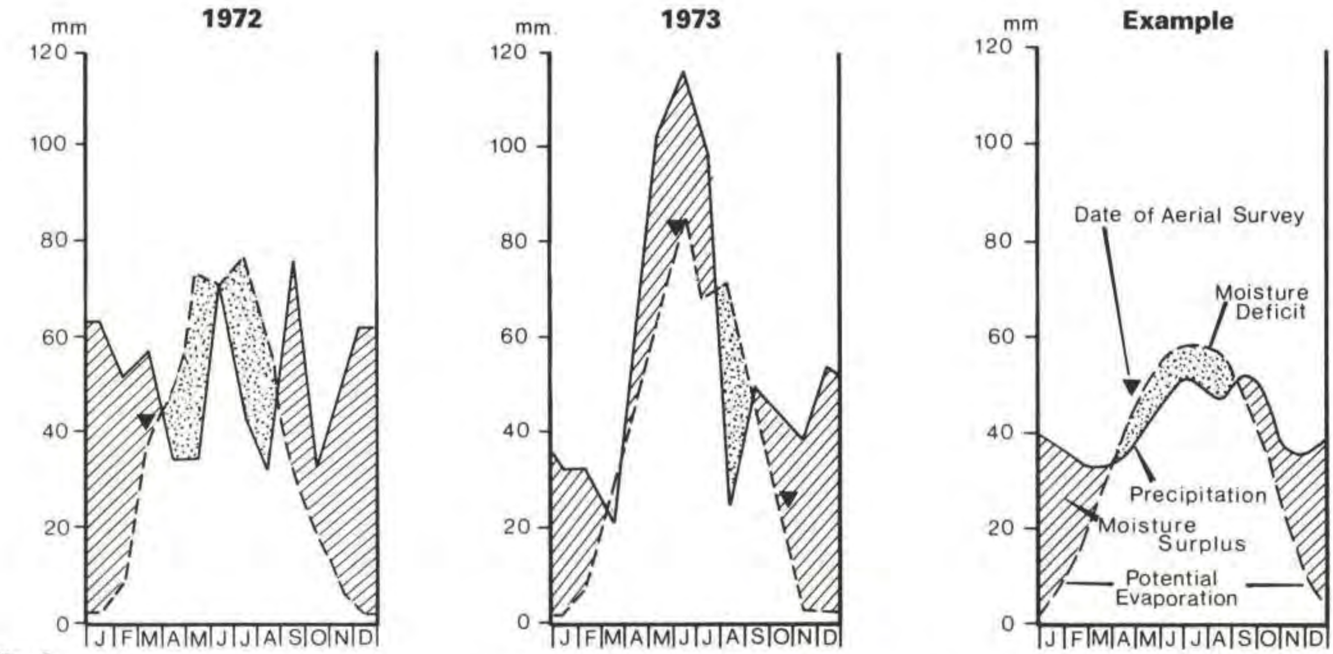


Fig. 3
Time of remote sensing related to moisture content. Tonal contrasts seen on aerial photographs should be greatest due to drying out of the soil as the moisture deficiency begins. The poor results occur during the moisture surplus conditions.

some success in finding shafts or workings. However, they still play a restricted role in the regular search for shafts, and there are several reasons for this.

Most of these methods are limited to detecting with confidence voids at depths from the surface of the same order as the void's size. (Ground-penetrating radar is one exception, but it requires very dry earth, an uncommon characteristic of sites in the United Kingdom.) Miners frequently covered over abandoned shafts with the waste from subsequent workings, and this burial often precludes the application of many of these methods. Secondly, most of these methods have poor discrimination. Mining sites are rife with features such as ash heaps and engine bases and these are frequently associated with anomalies similar to those of shafts. Choosing the most important anomalies requires considerable experience. Finally, some geophysical techniques, particularly those especially appropriate for locating shallow voids, are quite specialized and not readily available for widespread use. An attraction of divining is the ready availability of the 'instruments', and the minimal demands for training. Such aspects are desirable in effective methods for finding abandoned mine shafts, a task which is undertaken by many types of investigators in the course of land reclamation.

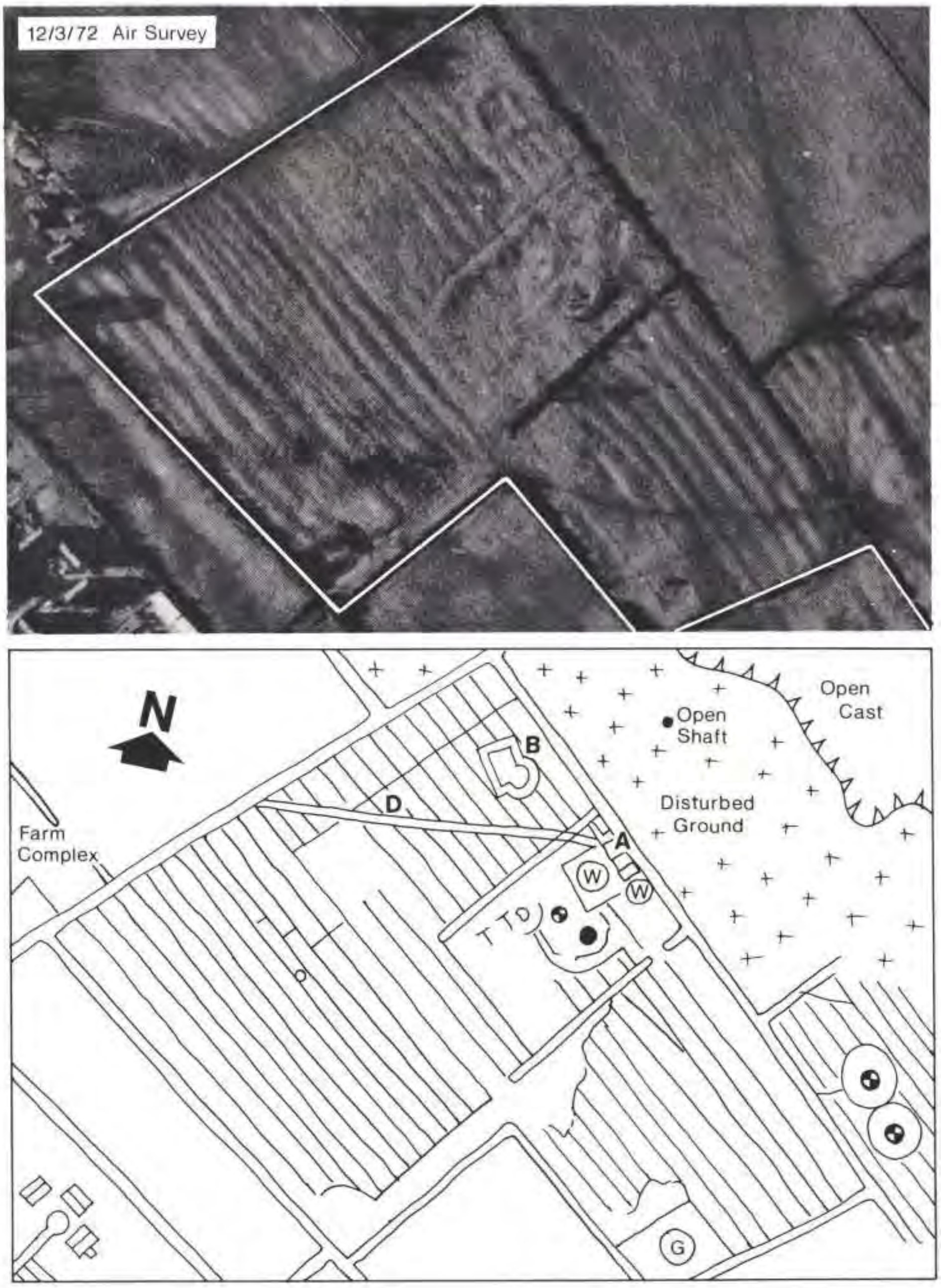


Fig. 4
Remains of agricultural and mining activity, area 2

Legend

- Furrows between medieval field strips
- (O) Mound with central depressions
- (W) Possible site of whim gin
- (G) Possible site of cog and rung gin
- **A** Possible site of buildings or stables
- **B** Building foundation
- **C** Houses
- **D** Track (possibly railway)
- Shaft probable
- Shaft proved

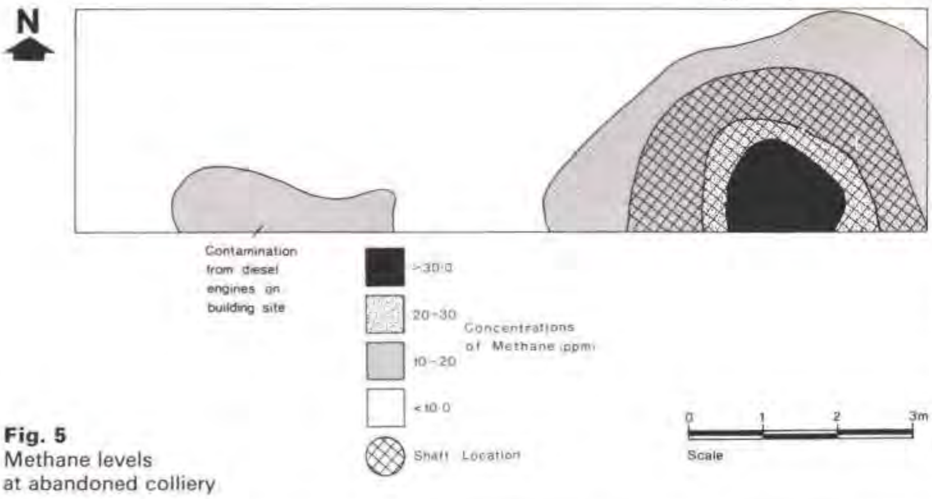


Fig. 5
Methane levels at abandoned colliery

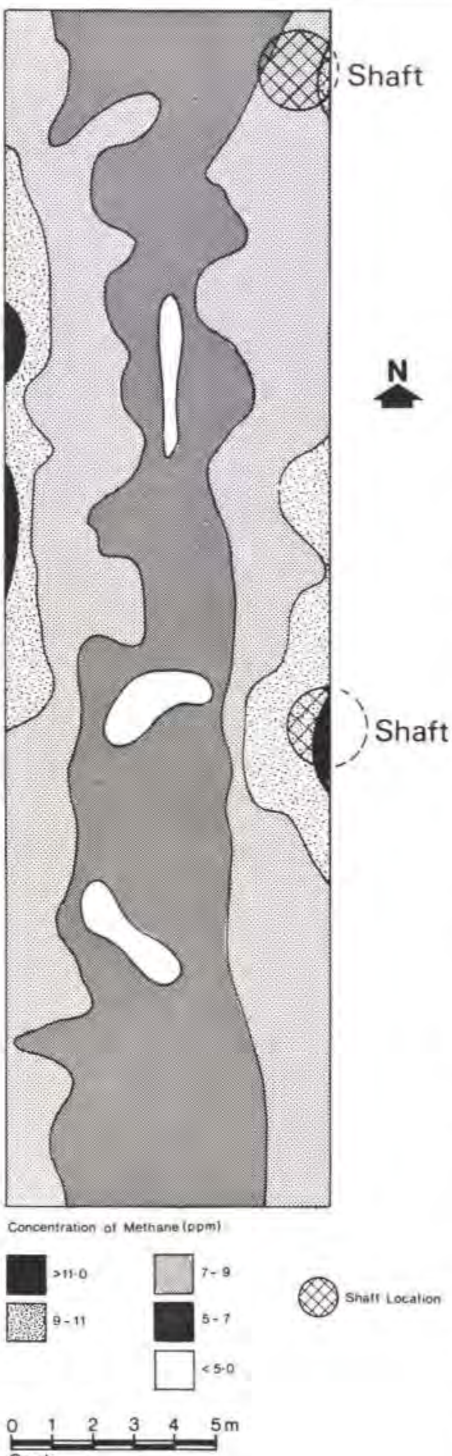


Fig. 6
Methane levels at abandoned colliery

Remote sensing methods – primarily aerial photography and infra-red sensing – do not have the ground penetration potential of geophysical techniques, but they are relatively straightforward in execution and interpretation. Black and white aerial photography taken in stereo during clear weather conditions and examined by an experienced eye can yield valuable information. There are several considerations in selecting the optimum time for the photography. Clearly, tonal contrasts from different soil types will be most visible from the air when there is minimal vegetation on the ground; therefore, winter or spring photography will usually be best.

The soil contrasts themselves will be most noticeable when there is a corresponding moisture contrast. This contrast is usually greatest in spring when a moisture surplus in the ground is changing to a moisture deficiency. A further advantage to winter or spring photography is that low sun angles of 20° to 30° to the horizontal accentuate minor topographical features with shadows that can greatly increase the effectiveness of aerial photography.

Figs. 1 and 2 are aerial photographs of the same mining area and illustrate the difference that the right conditions can make in shaft detection. Fig. 1 was taken on 12 March 1972, at 1610 hours. The long shadows and the good contrast in soil tones reveal numerous shafts as light rings. Fig. 2 was taken on 6 June 1973, at 1215 hours. This particular year was somewhat unusual in that June was still within a period of moisture surplus. The high sun angle, uniform crop cover, the atmospheric haze and the uniform ground moisture conditions combine to suppress the shafts' visibility. The moisture conditions for the two years in which the photographs were taken are shown in Fig. 3.

As part of a preliminary investigation of two sites included in the photographic coverage (Areas 1 and 2 in Figs. 1 and 2), a stereoscopic examination was made and the site was visited by the photographs' interpreter and an archaeologist. The result of the interpretation and the field check for Area 2 is shown in Fig. 4. The photograph in the upper part of the figure is an enlargement of part of Fig. 1. Most of the features could be identified from the initial examination of the aerial photographs. The area contains the remains of what are probably 17th century coal workings which interrupt a Medieval Field system. (The 'gins' referred to in Fig. 4 were winding machines, usually worked by horses.)

Besides the black and white photography, an infra-red scanning image had been made of the areas. This type of image shows the ground temperature with a resolution of about 0.5°C. An image of the site was made on 11 October 1973, at 1155 hours, which, as in the case of Fig. 2, was a period of moisture surplus in the ground. Only three mine shafts could be discerned on the image, while over 20 could be seen in one area of the photographs. A major contribution to the image's lack of success was probably the low thermal contrast between soil types at midday. Better results may have been obtained just before dawn when these contrasts would have been greatest, but it is still unlikely that there would have been a significant improvement over the good black and white photography.

What probably would have improved the aerial photography is the use of colour. This is because colour photographs have more tones than black and white. For an especially commissioned aerial survey, the added cost for the use of colour would be quite small. The cost of an entire aerial survey for most sites in the United Kingdom would be approximately equal to one or two exploratory boreholes at the site. Of course, if suitable photography is already available, the cost of obtaining photographs would be a fraction of this. Black and white stereo-photography already exists for virtually all areas where mining has occurred, and can be readily purchased.

In many cases aerial photography suffers the same limitation as geophysical methods: the alteration of the site by buildings or the dumping of wastes, subsequent to the end of mining operations, which obscures the top of the shafts.

A possible solution in the case of some abandoned coal shafts is to take advantage of the association of methane gas with coal workings. Methane is a familiar hazard in coal mining, where concentrations of more than 2 or 3 per cent pose a danger, and it is known that ignitable emissions of methane are associated with some abandoned shafts which have been left open. Capping and filling the shafts can significantly lower the emitted concentrations. However, very sensitive instruments for methane detection designed for hydrocarbon leak detection have recently become available. These instruments weigh only a few pounds, are easily operated, and can detect methane concentrations in air as low as 1 part per million (1 per cent equals 10,000 parts per million). By using this device as a survey instrument, it has been found in experiments that even filled and capped coal shafts may be located. Fig. 5 shows a methane map for part of an abandoned colliery site on which several shafts were known to exist. One of these had recently begun to emit methane concentrations of several per cent. The position of a second shaft was known, but was not revealed until after the survey. It was found that this shaft was emitting easily-detectable concentrations of methane through about 3 m of hardcore fill. The levels fluctuated by about a factor of 10 with barometric changes.

A second old colliery site, which had been turned into a pasture, contained several known shafts which had been completely filled but whose tops still reached the surface. However, they could not be seen and their positions were not indicated until after the survey. The methane map (Fig. 6) showed several prominent highs, one of which coincided with the position of a shaft. The other high concentrations appeared to be caused by mining waste on the surface. In this case it is uncertain if methane were leaking through the shaft or if it were simply being emitted from mining waste which was used to fill the shaft.

Typically, this indirect method serves to narrow down the area for subsequent investigation by excavation or drilling. Each of these two surveys took a few hours.

Methane detection has not been used extensively for finding abandoned shafts; its full potential is unknown. Like all the techniques for investigation discussed here, it must be used in the context of a full site investigation, after documentary research and before excavation.

The River Ouse bridge at York

Jorgen Nissen
Naeem Hussain
John Spalding

The road

The River Ouse bridge, which has now been named the Bishopthorpe Bridge, comprises part of the York Bypass which was opened to traffic last April. The Bypass takes through traffic on the A64 round the outskirts of York and relieves the present heavy traffic congestion in the inner town (Fig. 1).

The York Bypass was planned and designed by the Durham Sub-unit of the North Eastern Road Construction Unit. We were asked to design the bridge in the spring of 1971 and presented our scheme to the Royal Fine Art Commission a year later. Tenders were called in May 1973 for the whole contract. We had agreed with the Road Construction Unit that the River Ouse Bridge should be built in one contract with the road and the other structures. The contract was awarded to Dowsett Engineering Construction Ltd. who started work on site in November 1973.

The site

Of all the factors which together determine the design of a bridge, be they functional, engineering, economic or environmental, two had a particularly strong influence on the design of this bridge: the site and the soils.

The site is on a pleasant stretch of the River Ouse just downstream from York (Figs. 2 and 3). It is in an area of quiet, natural beauty frequented by anglers and walkers and it provides an important amenity for the people of York. The Archbishop's Palace and two other listed houses stand close to the site. Barges and pleasure boats use the river.

There is a marked difference between the two river banks. To the west, the road crosses a wide flood plain on a long embankment; to the east the ground rises quickly and the embankment is much shorter. This difference is emphasized in the soils below (Fig. 4). The poorer soils, alluvial deposits of silts and soft clays, tend to be much thicker under the flood plain than under the east bank. These strata are of very variable composition from soft to very soft and they contain traces of organic material.

The embankment

Before the bridge design could proceed in earnest it was necessary to study the embankment across the flood plain. It was by no means certain that an embankment could be built within a reasonable period on the soft deposits and it was therefore possible that the bridge would have to extend over most of the flood plain.

The problem was mainly one of obtaining useful information. The important strata vary considerably over the site in both magnitude and composition and one of the most important parameters, the permeability, is notoriously difficult to determine on small samples.

In the event, the decision to build the embankment was based on tests on samples from a number of boreholes, on experience from similar sites and on empirical relationships known to exist between the different soil parameters.

The test results showed the expected wide variations, except for a remarkable consistency in the effective shear strength. This was sufficient to support the embankment in the long term. The undrained shear strength, however, varied widely, but a safe value suggested that half of the embankment could be built quickly but further filling should wait

Fig. 1
The York Bypass will take through traffic on the A64 Leeds/Scarborough trunk road round the city of York. It will be a dual, two-lane road to near-motorway standard. 18 bridges have been built on the 14 km long road. We designed the River Ouse Bridge; the road and the other structures were designed by the Durham Sub-Unit of the North Eastern Road Construction Unit

Fig. 2
The Bypass crosses the River Ouse at the end of a wide flood plain close to the Palace of the Archbishop of York

Fig. 3
The site is pleasantly wooded. The river banks are closely overgrown and there are plenty of trees and bushes on both sides of the river (Photo: David Faggetter)

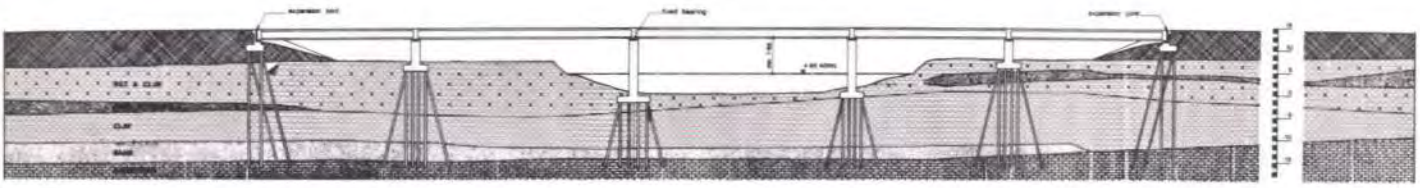


Fig. 4
The soils are alluvial sands, silts and clays on glacial deposits of sands, gravels and clays. The thickness of individual layers varies considerably along and across the profile. Bedrock is Triassic sandstones at approximately 18 m depth

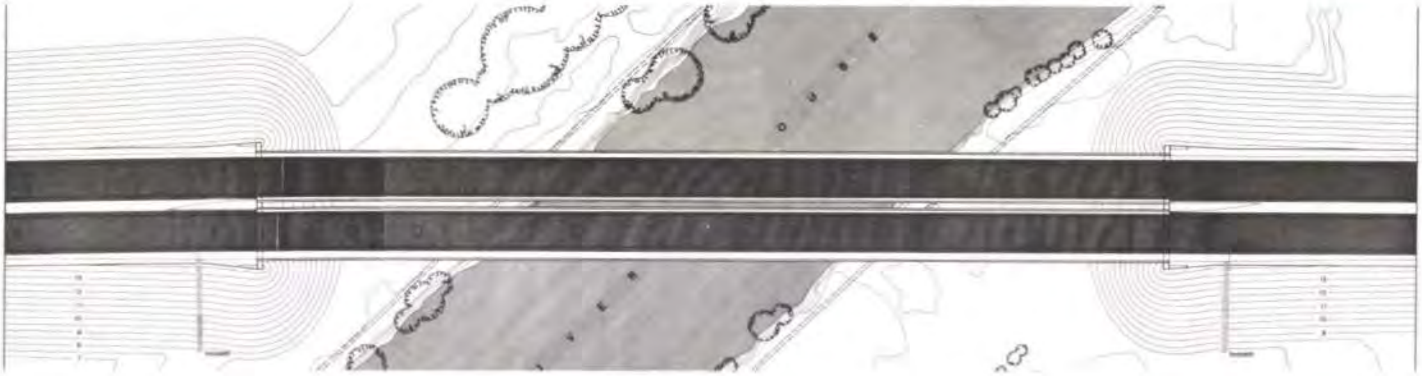


Fig. 5
Plan of the bridge

for the pore pressures to dissipate and for the consequent gain in strength to take place. It was expected that this would happen within the contract period, and the decision to build an embankment was therefore taken.

Subsequently, the Road Construction Unit had centrifuge tests carried out at Cambridge. They confirmed the original opinion. The embankment was eventually built in two stages, half being built in a special contract before the main contract, in which it was completed. Vertical and horizontal movements and pore pressures were measured throughout the construction period so that the safety of the embankment could be assessed at any time.

The bridge

The embankment study showed that although a stable embankment could be built in the flood plain it could not be built too close to the river banks. This in a way was fortunate. The road severs the landscape, particularly when it is on embankments, and a longer bridge gives a wider field of view under the bridge. The abutments have been kept well back from the river banks (Fig. 10). The most important element in the landscape, the river, can keep its natural character as the river banks are allowed to remain undisturbed on both sides.

The crossing is skew and this is always a problem, particularly when the road is very wide. In this case, the problem has been solved by dividing the bridge into two independent bridges. Each of these bridges is supported on single columns at right angles to its axis (Fig. 5). The river columns on the two bridges are placed on the skew, parallel to the river banks, whereas the land columns and the abutments are at right angles to the road.

This gives a good structural layout but the plan or the elevation may seem confused at first sight. We compared it in models with more conventional layout (skew on land) and it actually looked better. The embankments are high and dominate the landscape and it seemed more natural that they were terminated at right angles than at skew; it also seemed right that the columns on the banks close to the abutments should relate to the abutments and that the river columns should relate to the river (Figs. 6 and 7).

The structure

It was important to keep the embankments and therefore the bridge as low as possible so that both the load on the soils in the flood plain and

Figs. 6 and 7
The river columns relate to the river, the columns on land to the abutments

the visual impact of the embankment would be the smallest possible.

The bridge is therefore at low level – its height was determined by navigation clearances – and it is very wide. It then seemed appropriate that the structure should be underplayed so as to be sympathetic with the landscape, and shaped so as to soften the impact of the heavy structure so close to the ground.

Many structures were studied and a box structure in prestressed concrete was chosen as the most advantageous (Fig. 8). This structure was developed to its final form (Fig. 9).

The shape of this box is perhaps the most special feature of the bridge. The soffit slabs have been made as curved shells to give the structure a light appearance. This shape has given an efficient structure; prestressing cables are draped in the shells between the top, at the supports, and the bottom, at mid-span, and therefore have maximum eccentricity at the critical sections. This particular shape has also made it easier to handle the different cross falls and widths of the two bridge halves.

The columns were difficult to design, models were used and in the end the simplest solution turned out to be the best. All columns are piled.

The abutments are simple bank seats on piles. The embankment slopes are taken around the abutment seat in a gentle curve that echoes the curves in the deck soffits and the columns.

Construction

The original two-year contract period was extended, mainly due to the shortage of materials created by the three-day week at the start of the contract. This was felt particularly at this bridge. The most consistent shortage was of steel which was needed early in the contract for the steel piles, for cofferdams and for support works for the shuttering. Work on the bridge did not, therefore, start in earnest until four to five months into the contract period.

The piles are driven steel H-piles founded in the sandstone. The piles at the abutments were slip-coated to reduce draw-down loads created by settlements under the embankments. The bitumen coating was poured hot onto the piles to a thickness of 8 mm. The piles were then whitewashed to prevent flowing and, in very sunny and warm weather, shades were provided. In gravel layers, cased holes were prebored and backfilled with p.f.a. to protect the slip coat during the driving. All piles are protected below the lowest water level by zinc spray and pitch epoxy paint.

All concrete was cast in situ. The columns and pilecaps in the river were cast within cofferdams. All columns were cast in one lift. The deck was constructed span by span with each span being stressed onto the last span before the next span was cast. Shuttering was supported on falsework, on patent scaffolding frames on land and on steel beams over the river.

All shutters were made from rough sawn boards. Douglas fir was specified but the contractor offered an alternative made from spruce which had a prominent raised grain feature. It has given an excellent finish. The boards were planed down to the same width but no attempt was made to adjust the varying thickness of the boards. A fairly liberal application of shutter oil gave a clear strike and good usage of boards. The rough boards on the soffit formwork gave rise to some problems. Such boards are often in position for a long time before concrete is cast and care has to be taken so that dirt does not collect and the raised grain is not damaged.

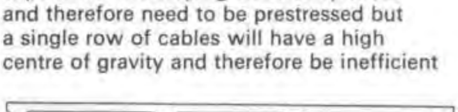
The total prestressing force in the longest span exceeds 7000 tonnes. The VSL system of coupled cables was used. The stressing operations progressed without difficulty.

(a)

Single cell box: well known reference structure. Well suited, but heavy in appearance

(b)

Lighter in appearance but more expensive. The sloping slabs carry shear and therefore need to be prestressed but a single row of cables will have a high centre of gravity and therefore be inefficient



(c)

The chosen cross section. Light in appearance. The cables in the shell can be draped between the top over supports and the bottom at mid span and therefore have maximum eccentricity at the critical sections

Fig. 8
The development of the cross section

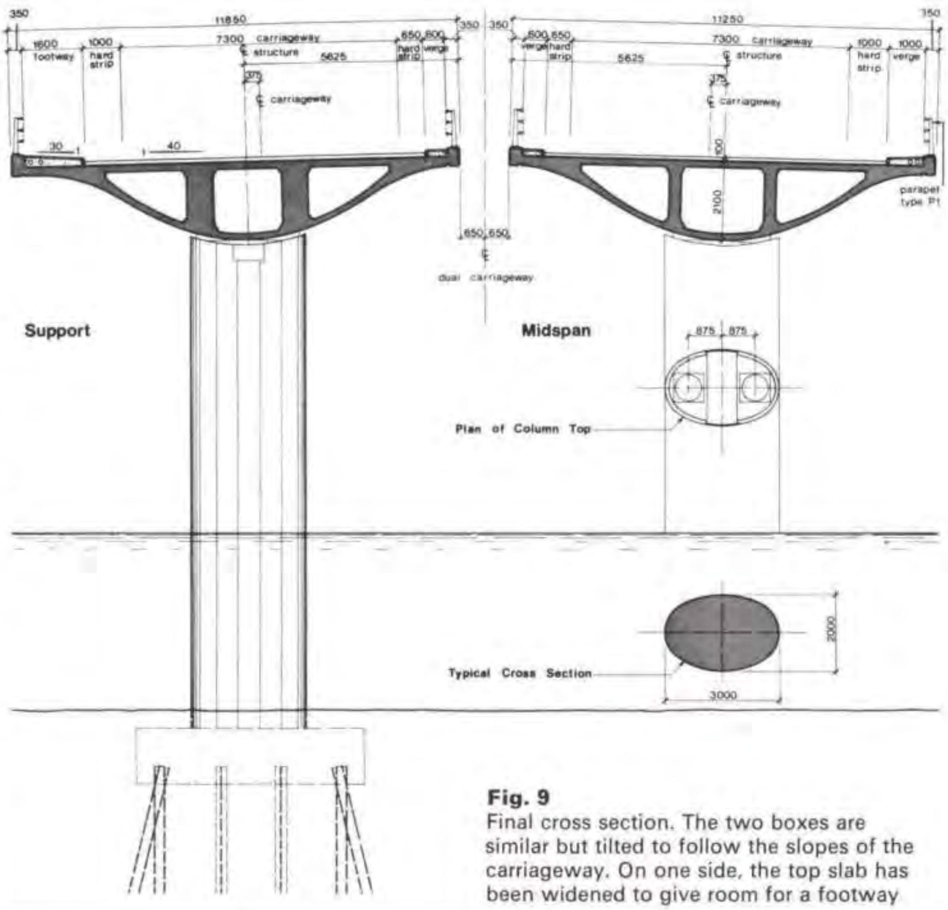


Fig. 9
Final cross section. The two boxes are similar but tilted to follow the slopes of the carriageway. On one side, the top slab has been widened to give room for a footway

Fig. 10
The abutments are well back from the river banks and the character of the river is kept

Credits

Client
Department of the Environment

Designers
Civil Engineering Division, Ove Arup & Partners

Main contractor
Dowsett Engineering Construction Ltd.

Fire safety in buildings: The design approach

Margaret Law

Introduction

It is not surprising that the importance of achieving a deeper and wider understanding of fire engineering is now widely recognized. Where buildings are concerned, changes during the past three decades in design and construction and in the ways people want to use buildings have meant that some of the traditional fire safety measures have been found to be restrictive and not necessarily effective. For these reasons a whole new body of information on fire behaviour has been obtained and a significant change of approach to methods of saving life has been developing. Fire safety is now considered at an early stage of the design of a building and the objectives of providing fire protection are clearly defined from the start. Using the information which is now available it is then possible to assess how the various features of the building design will interact with the fire safety measures. The fire engineering design approach has a number of advantages: it avoids the expense and inconvenience of patching in the measures at a late stage and, more important, it will be more effective and will more closely meet the needs of the owner and users of the building. When we are working on buildings outside the UK this approach is especially useful because, as with other branches of engineering, we can take into account the local conditions rather than try to arbitrarily apply codes and rules of thumb developed for use in this country. Design manuals will soon be available covering many aspects of fire engineering in buildings and indeed we ourselves are involved in this work.

Changes in buildings

The most obvious change in building design which has affected fire safety is increase in size. There are more tall buildings and there are more buildings with very large uninterrupted floor areas. A large building means that more people and more property are put simultaneously at risk and therefore there is greater potential for a disaster and a greater maximum likely loss. An increase in size can make the fire itself more severe and can increase building stress because a large area of structure may be heated at one time. A tall building poses obvious evacuation and fire fighting problems (in addition to difficulties of access in congested streets), and the various services which people require, such as lifts and heating and air conditioning systems, tend to assist the spread of fire and smoke, while structural collapse could have serious consequences on the surroundings. Then there are buildings which need to have very large open areas so that people can move around freely, as in department stores and covered shopping centres, or so that goods can be moved unhindered, as in factory assembly lines. Here again, evacuation and fire fighting can be more difficult and there are few physical barriers to the spread of fire and smoke. Because of these increases in size, compartmentation, the traditional method of restricting fire and smoke spread by providing fire-resistant walls and floors as barriers, may be less effective or even non-existent; fire fighting is more difficult, escape via windows unlikely, and structural behaviour may be more complex. Consequently there is now much more emphasis on the design of means of escape and especially on the use of active methods of fire protection, such as sprinklers and the control of smoke movement.

The second major change has been in the methods of construction, in particular lightweight cladding with little or no fire resistance, prefabricated units and built-up assemblies rather than the more monolithic brick, block or concrete elements. When traditional walls with fairly small windows were replaced by lightweight cladding with large areas of glass, it was realized that this could increase the fire exposure of nearby buildings. A research study was therefore made of the relationship between the external fire exposure hazard and building separation and produced the first 'fire engineering design approach' which was explicitly incorporated in building regulations. Every joint and fixing in a building assembly is a potential weak spot where fire protection is concerned and if cavities and voids are not divided by barriers then fire can spread unnoticed throughout a building. Once stated, this seems obvious enough, and what is needed here is careful attention to detail and better quality control. Even with the well-tried structural systems – concrete, steel, timber, brick and block – the introduction of limit state design may mean that certain features of over-design which have been unwittingly relied on for fire safety in the past may not be present in future buildings. The design approach for structures is therefore of some importance.

The third major change is in the type of building materials used – in particular plastics – and their propensity to spread flame and produce smoke and toxic gases. Combustible structural materials are not in general the prime cause of death by fire – the contents usually are – but it is important that they should not increase the smoke problem unduly or release large amounts of toxic gas, particularly where fire-fighters are concerned, nor help to spread fire rapidly. They are also, of course, more likely to be lost or irreparably damaged by fire, increasing the problems of reinstatement. The objective is to learn how to use these materials with reasonable safety, as we already do with wood, rather than to ban their use completely.

As a result of these major changes, the effect of building design and building regulations on life safety will be much more direct than in the past. We are seeing for the first time a new approach to fire safety measures in buildings and this can be demonstrated by considering the objectives and the measures available to meet them.

Objectives and measures

The objectives of providing fire safety seem obvious enough but it is worth setting them down because their relative importance can have a significant effect on the building design. They can be itemized as the protection of life, the protection of other people's buildings and the protection of the contents and structure of the buildings on fire. The first two – the mitigation of the life hazard and the exposure hazard – are usually considered to be the basis of building regulations requirements while the third – the mitigation of the damage hazard – is considered to be a matter for the building owner and his insurance company. Where structural adequacy is concerned, the main effects of the fire resistance requirements of the regulations are to safeguard escape, restrict fire size and protect fire fighters; they do not ensure adequacy of the structure after a fire has occurred, nor do they necessarily protect the contents of the building, but these aspects may be very important. In addition to direct loss, the indirect loss may well be serious, for example loss of production, or we could consider the situation of an isolated hospital which might well have good means of escape, yet if it is so severely damaged by fire that it cannot be speedily reinstated, the subsequent danger to life can be considerable. On the other hand, an automatic stacking warehouse has a very low life hazard, and if the contents are very valuable there may be little point in trying to save the structure, should a fire occur, provided it presents no exposure hazard.

Fire protection measures can be considered under two headings: active and passive. Detectors, alarms, sprinklers and control of smoke movement are active measures and in the main have been developed to reduce the damage hazard. Passive measures are inherent in the design and layout of the building.

Compartmentation, restrictions on the use of combustible materials, and structural fire protection – the application of protective material to the structural elements of a building – are all passive measures. They reduce the damage and exposure hazard and are also the principal measures required by building regulations. However, it is difficult to demonstrate that the passive measures have had a great impact on life safety, since until recently most fire fatalities have occurred where there has been little fire spread beyond the room of origin. It can be inferred that the regulations have been developed in the main to reduce the risk of a disastrous conflagration. Now, because of the changes in building design described earlier, there has been a significant change of approach. First, a recognition in regulations that there can be a 'trade-off' of passive against active measures, for example that larger compartments can be permitted if sprinkler systems are installed. Second, that the design of the building to restrict smoke spread and the use of active methods of smoke control can have a direct impact on life safety. It is for this reason that it is now worthwhile and important to study how people are likely to behave when a fire occurs in a building and to allow for human behaviour in the system of fire engineering design.

Fig. 1
Centre Pompidou, Paris (Photo: Mike Sargent)

Fire safety measures and the design approach

Structural fire protection is the most commonly used passive measure and the adequacy of structural elements is assessed in a standard furnace test. Fire resistance is expressed as the period of time from the beginning of the test for which an element satisfactorily performs its function. Since a standard temperature-time curve is used, while in practice fires will produce a variety of curves, the period of fire resistance is not necessarily the same as the survival time in an actual building fire, although the integrated temperature-time effect may be equivalent. This equivalent effect can be determined because it is now possible to show how the amount of fire load, the ventilation and the compartment size interact to affect the fire behaviour in the building, and to relate these to the fire resistance required by a structural element to survive a burn-out. We did such an analysis for the International Merchandise Mart and were able to show the effect of very large compartment size on the fire resistance needed for the structural elements. (In fact, with the very large size contemplated, expansion of the floor slab would be at least as important as the grade of fire resistance.)

Fire resistance

There have been considerable studies of the 'rational' design of fire resistance of concrete, steel and timber structures which will undoubtedly improve existing codes. However, the fire resistance test does have limitations. It does not assess repairability nor does it measure how the element will perform when it is assembled as part of the building structure and there are two possible developments of the test which would be of great interest to designers. First, an assessment of the residual strength and repairability and, second, measurements which could allow extrapolation of the results to assess behaviour of the element when assembled in the building. The test is designed for average fire conditions and may be unrepresentative of certain fires, for example in petro-chemical plants or where there are large stores of plastics materials. It is also unrepresentative of the fire exposure of external structural elements and, instead, a fire engineering design approach has been adopted to assess the external heat transfer. In the past this approach has been used for specific buildings – the Centre Pompidou in Paris for example – but sufficient data are now available to give general guidance and we have already developed, for Constrado, a calculation method for the design of external steel columns without fire cladding for office buildings. We will shortly be completing a calculation method and design manual covering the use of both external columns and beams without cladding for a range of building types, this work being on behalf of the American Iron and Steel Institute and Constrado.

Smoke Movement

Some years ago a systematic study in this country was made of the design of roof venting for the release of smoke in single-storey buildings with the objective of assisting fire fighters and thus reducing the risk of fire spread through the building. Recently this work has been carried further to solve the problem of smoke control and removal in covered shopping centres. In these developments, sprinklers are used to limit the size of the fire and hence the smoke generated to an amount which can be coped with by the extraction system, the design being based on a statistical and experimental estimation of the maximum likely size of fire. An alternative to smoke removal is to use a positive measure to hold back the smoke; pressurization of corridors and staircases has been developed for this purpose so that when a fire starts in a room, smoke will tend to flow out of the windows rather than through the door back into the building. This method seems particularly promising for tall buildings such as offices and hotels and sufficient design data are now available to form the basis of a code of practice.

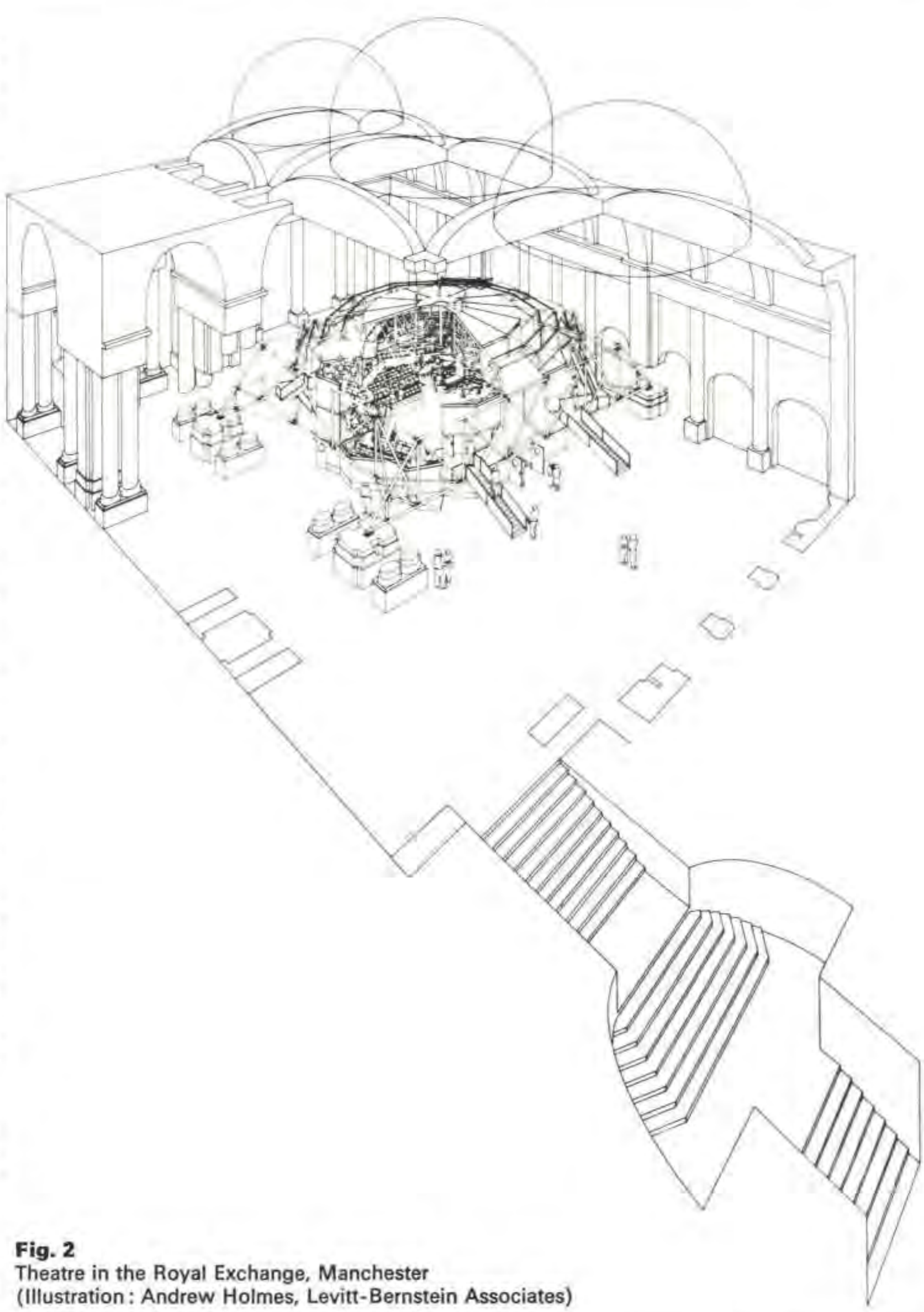


Fig. 2
Theatre in the Royal Exchange, Manchester
(Illustration: Andrew Holmes, Levitt-Bernstein Associates)

We were able to apply the published design data on fire growth and smoke generation to solve an unusual problem posed by the Royal Exchange Theatre. This theatre is a tubular steel structure of about 3,500 m^3 volume standing inside the vast hall of the Manchester Royal Exchange, which is about 50,000 m^3 in volume. We established that the main objective was to ensure that people would be able to leave the auditorium and the hall within the normally accepted evacuation time for a theatre. By estimating the maximum likely size of fire and the rate of smoke accumulation, and by analyzing escape paths, we were able to show that evacuation would be expected to be complete well before smoke logging of the hall would present problems.

Costs

There are at least two aspects of fire protection where it is difficult at the moment to put any data into the design equations. One has already been mentioned and that is human behaviour. The second is the cost of fire protection; the cost effectiveness of a measure will depend on the objectives and who makes the decisions. What it is worth to save a life is mainly decided by society and, as with other forms of safety, society expects more to be spent per life saved for the potential disaster situation. There are some data on costs of fire protection and property loss which are probably more useful on a national basis than for the individual building owner. At present, the fire engineer can best assist the client by helping to establish the objectives and then designing the measures so that they meet these objectives alone. He should also take into account how people will actually use the building, since fire safety measures which interfere with the normal running of the building are likely to be rendered ineffective.

Concluding remarks

Now, building design is likely to have a much more direct effect on life safety and property loss than in the past and a fire engineering design approach is essential. The most significant development is that measures which have been mainly used to reduce property loss will in the future be adopted to save life as well. Very shortly we will have a much more clearly defined basis for the fire engineering design of buildings. Much remains to be investigated but the basic lines of approach are becoming established. This involves the work and co-operation of research workers, building code officials and practising engineers and we are actively supporting these activities.

Keble College, Oxford

John Tyrrell

Post-war Oxbridge contains numerous examples of well-detailed buildings each reflecting the highly individual style of the architects responsible. The residential building for Keble College, Oxford, readily falls into this category and has already been illustrated in the architectural press. The architects, Ahrends, Burton and Koralek, have resolved a number of problems peculiar to this site and in the process have produced a building of stature that not only enhances the townscape but also enriches an already rich heritage.

The site, as shown in Fig. 1, is defined by the existing college buildings to the east, Blackhall Road to the west and Museum Road to the south. There is a gradual slope across the site commencing roughly from the narrowest part on Blackhall Road.

The brief required, in addition to the present residential accommodation, a further 89 study bedrooms for graduates and undergraduates, 13 Fellows' rooms and two Fellows' flats. Additional amenities to be provided include an M.C.R. and bar (The Middle Common Room apparently being the mixing bowl for undergraduates, graduates and Fellows), car parking facilities and cycle storage. The building, financed by the Hayward Foundation, was scheduled to be constructed in two stages. Work on Phase 1 commenced on site in 1971 and was completed towards the end of 1972. Phase 2 commenced on site early in 1975 and completion is anticipated later this year. It was originally intended that Phase 2 should directly follow on from Phase 1 but financial reasons prevented this and special provision had to be made in the servicing of the buildings for the lack of continuity.

Although no formal planning requirements were to be satisfied, clearly one of the major design problems to be resolved was the sympathetic co-existence with the existing buildings designed by William Butterfield. Figs. 2 and 3 are copies of the original drawings which illustrate the rather monumental proportions typical of the buildings of that era (*circa* 1870). The brickwork has an imposing presence and exhibits a variety of ornate patterns and colours, which are particular trademarks of Butterfield. The new building has been constructed with present-day materials and it is very definitely not trying to copy the existing buildings.

The awkward shape of the site has, to a large extent, organized the planning of the building. The site boundaries are articulated by the narrow width which is a room's depth ending up with an open quadrangle at the largest part of the site. Fig. 4 is a typical floor plan and illustrates the staircase which serves rooms on either side of it at each level in the traditional manner. For each staircase, there are toilet and washing facilities forming a number of service towers which are expressed on the external elevation. This cellular effect is heightened still further by the glazed inner façade revealing the life of the building yet reflecting the outside, whereas the external brick elevation presents a rather introspective face to the outside world in common with most other colleges. The covered walkway at ground level provides the main circulation around the inner perimeter.

The structure is relatively straightforward and consists of reinforced concrete floor slabs spanning between loadbearing brickwork and blockwork crosswalls. Beams have been discreetly introduced to deal with the somewhat artificial requirements of the 5th Amendment. The brick crosswalls are highly stressed at low level and, in order to minimize any differential ground movements, the building is founded on a grid of piled foundations. Due to the proximity of the existing building and thus the need to reduce vibrations and noise, the Dowsett system of Prepakt Piles was utilized. The pile is constructed by boring the auger into the ground in a continuous operation with no soil being removed during this procedure. When the auger has reached the required depth, intrusion mortar is pumped under pressure through the hollow shaft of the auger into the bottom of the pile. The pressurized injection of the mortar continues until the auger, with its load of bore spoil, has been removed from the ground and the hole completely filled with mortar. The reinforcement is then added whilst the mortar is still fluid. (A footnote to anyone wishing to view the system – Wear your boots!)

An interesting feature is the spiral stair at one end of the building serving the Fellows' accommodation. This was published as a working detail in *The Architects' Journal* and is reproduced here in Figs. 5 and 6.

The restricted budget has, not unreasonably, affected the choice of applied finishes and structural materials. At an early stage it was decided to keep the applied finishes to a minimum and express the structure. This, of course, placed extra demands on the quality of workmanship as well as blending the concrete with the brickwork. The external brickwork generally and the internal brickwork to the walkway and staircase are in yellow/buff handmade facing bricks set in similarly coloured mortar. Walkway and external brick pavings also match the brickwork. The bands of concrete contained in these brickwork faces are cast in fairfaced white concrete. The windows and flashings are in aluminium, finished in dark brown acrylic paint with brown tinted glass.

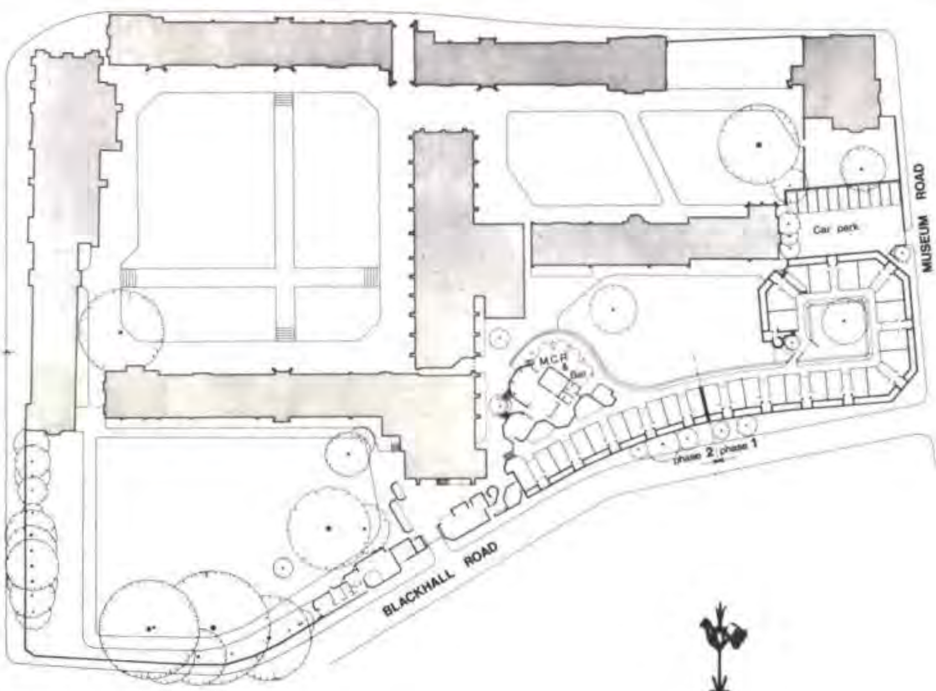


Fig. 1
Site plan

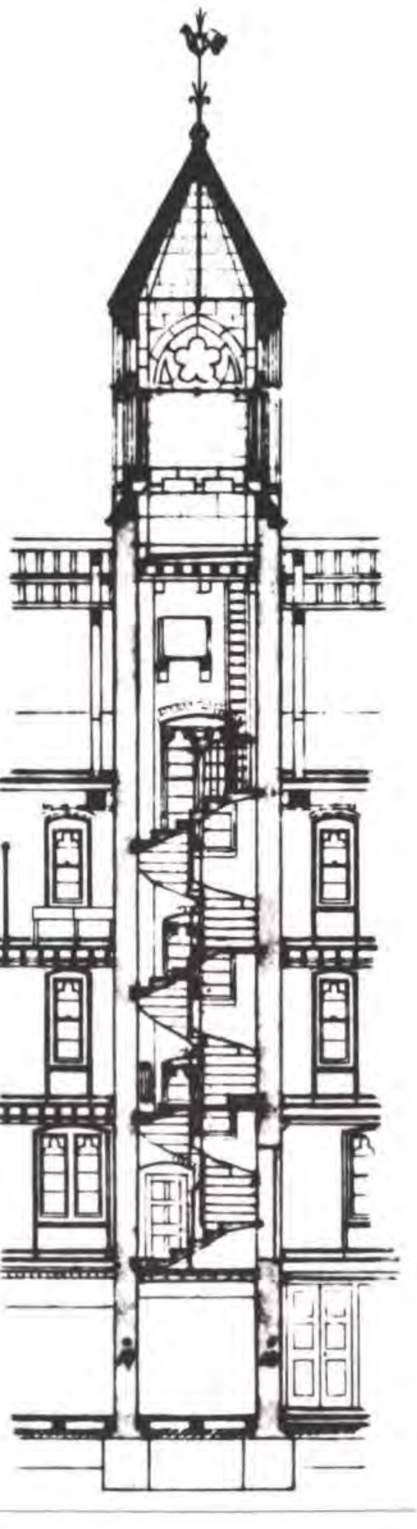


Fig. 2 right
William Butterfield's Keble College – section through Tower

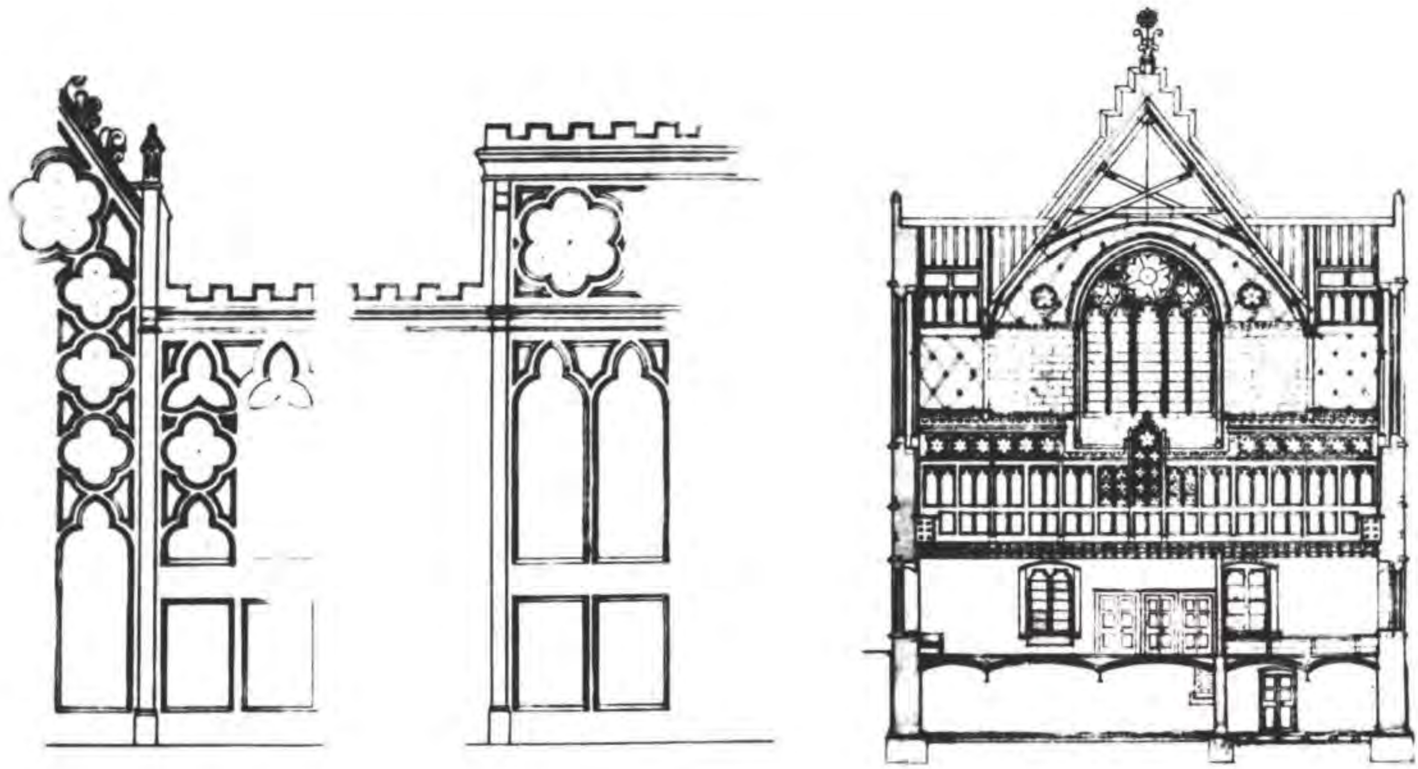
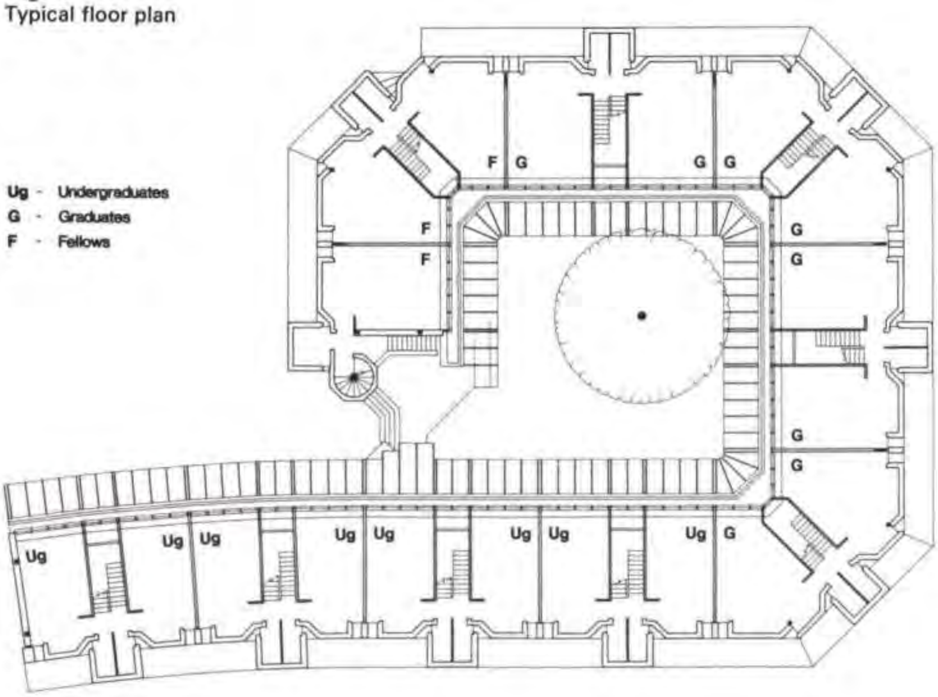


Fig. 3
Section and detail of west end of the Dining Hall

Fig. 4
Typical floor plan



The sloping glazed façade exhibits a certain 'greenhouse' elegance and reflects a rather curious imagery apparent from virtually any angle. Figs. 7–15 help to illustrate the main aspects of the building.

It is significant that the college authorities have actively encouraged an adventurous style and they have not been altogether inactive. The choice of brick was of major concern to the college and vigorously pursued by the Building Sub-Committee. A process of academic elimination followed, recognizable to those avid readers of C. P. Snow, before the concept of a bridging colour between Keble and Oxford Stone was adopted.

The concluding remark should belong to the Poet Laureate, Sir John Betjeman, also an Honorary Fellow of Keble, who says in the Oxford Diary 'I do not think Butterfield would have objected'.

Credits

Client:
Keble College Oxford
Architects:
Ahrends, Burton and Koralek
Consulting Engineers:
Ove Arup & Partners
Main contractors:
Phase 1:
Johnson and Bailey Ltd.
Phase 2:
Benfield and Loxley

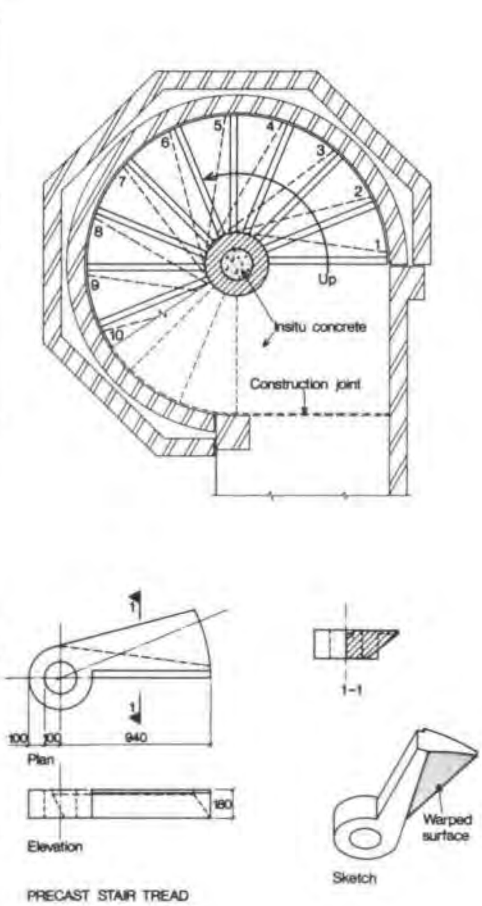
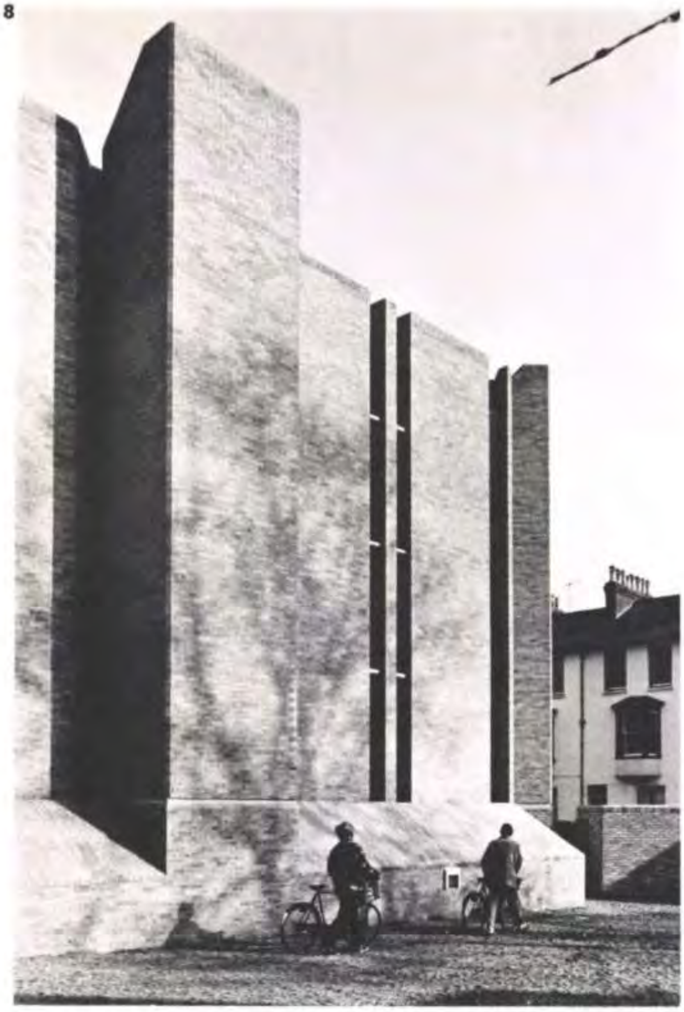


Fig. 5
Spiral stair detail

Fig. 6
The spiral staircase
(Photo: John Donat)

Fig. 7
The circulation area
showing the Butterfield building

8



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Figs. 8-15
Details of the new building
(Photos: John Donat, except Fig. 11 by Frank Gadd)

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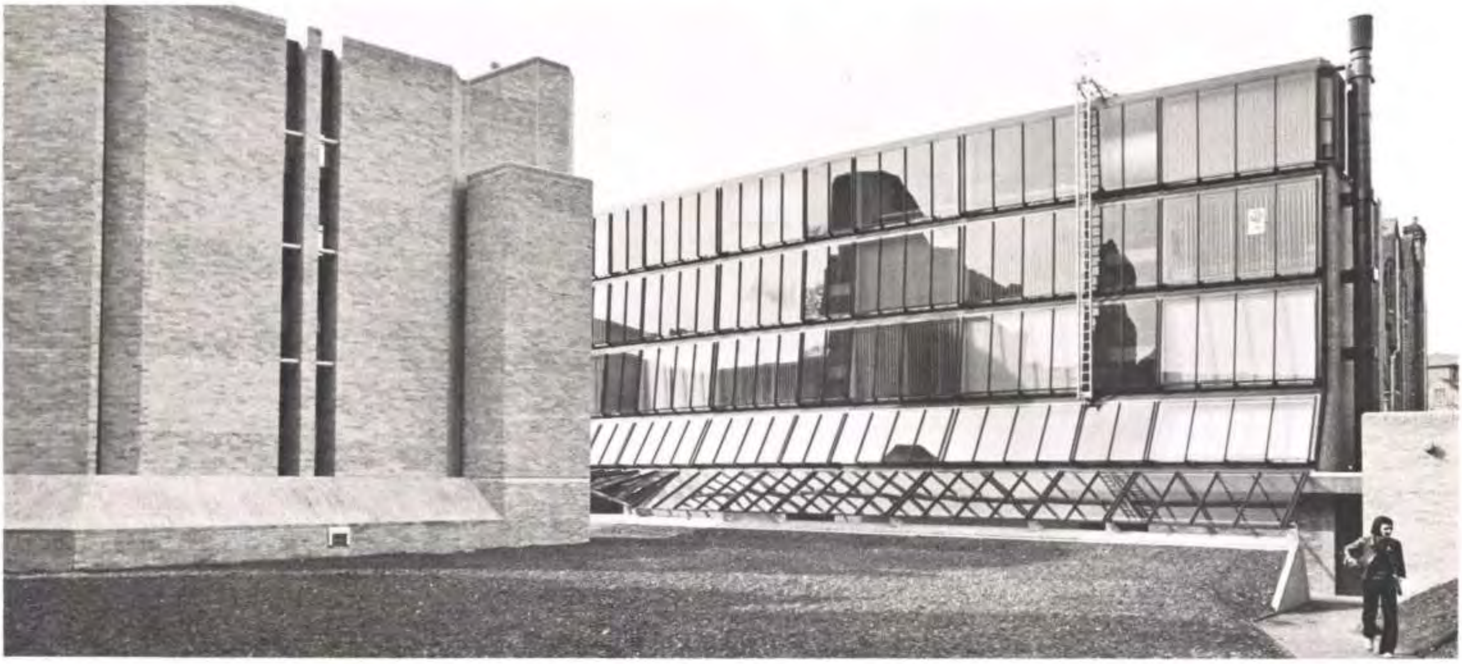

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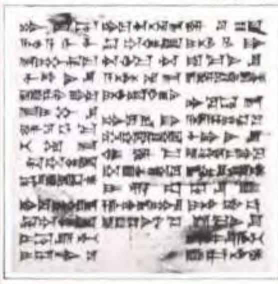

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