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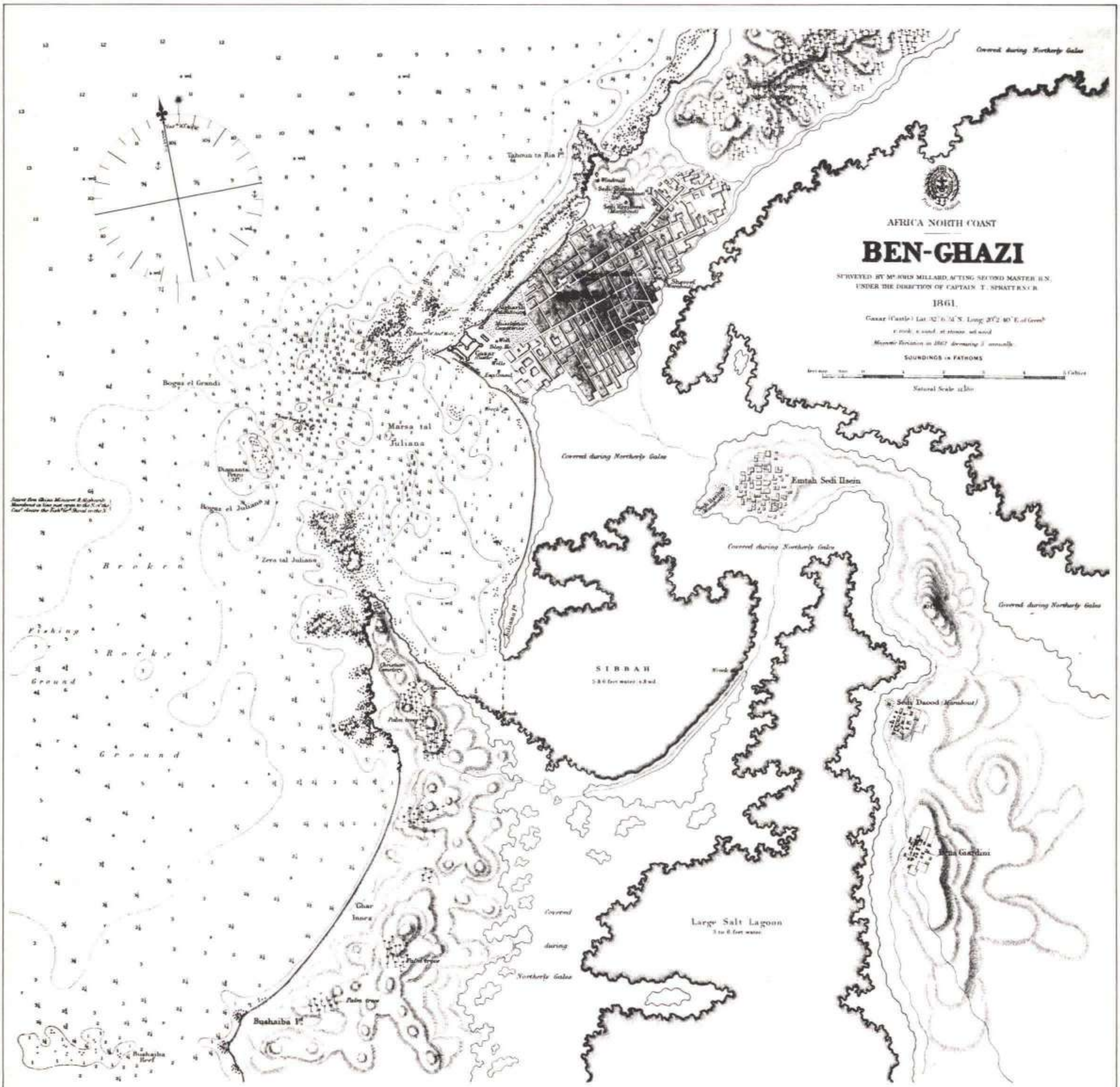

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Front cover: Map of Benghazi, surveyed in 1861.
Back cover: Tate Gallery extension – main gallery showing typical 9m square bay (Photo: Henk Snoek)

Some recollections from the '30s

Ove Arup

To be asked, at very short notice, to write an article on the architecture of the '30s – presumably from an engineering aspect – is a tough assignment.

The subject is vast, there is no time to sort out and consult the large amount of stored up evidence to jolt the memory and check its accuracy. All I can do is to write down some memories about what the '30s meant to me. I speak as an outsider – a double outsider, in fact – a foreigner among the British and an engineer among architects. It is axiomatic, of course, that a foreigner can never hope to understand the British, nor an engineer architecture. But otherwise, being an outsider has its advantages. And I was, of course, not the only foreigner in the game, for the 'Modern Movement' in Britain was at that time essentially a foreign import. It was by definition international, being steered by the prophets of the movement organized in CIAM (Congres Internationaux d'Architecture Moderne), with branches in the countries which were sufficiently awake to receive the message. Britain was considered rather backward in this respect, but with the help of a few disciples who had worshipped at the shrine of the masters, a propaganda centre, the MARS Group, was established. According to some undated 'Regulations' of the Modern Architectural Research Group I found in a MARS file, the objects of the group were:

(1) The Association of Architects Engineers and Allied Technicians and other persons for the purpose of furthering an architecture to serve the needs of Society.

(2) To co-operate in furthering and supporting the aims of the National Groups organized in other countries who are associated in the International Congresses for Modern Architecture.

Those who were also members of CIAM were automatically honorary members and did not have to pay a subscription. Obviously they were the élite. This was modified later, but the pecking order tended to be defined by closeness to the source. I became a member of the group shortly after it was formed. Being a foreigner and an engineer was no obstacle but I was, of course, supposed to agree with the objects of the Group and be prepared to participate 'effectively'(!) in the realization of its programme. Which I did, and was – but with some reservations.

To explain these reservations I would have first to say a few words about my own situation. If this article ends up dealing more with me than with architectural history it is not because I wish it so – it is simply because that is all I am competent to deal with, and even then it is probably unavoidable that some hindsight will creep into the story.

Early days

I had studied philosophy for three or four years at Copenhagen University during the First World War, and had then embarked on a five-year study of engineering, because philosophy could not solve the riddles of the universe or the conundrum of the human predicament. Truth evades us, but we can make things, and if what we make is good, we feel good. That, in short, was my argument, and I knew I could become a good engineer – I was not sure about becoming a good architect or artist, and being a second-rate one didn't appeal to me. Towards the end of my studies I specialized in reinforced concrete because this exciting new material obviously had a potential which was still waiting to be exploited. And in the beginning of 1922 I was lucky to be employed by a Danish firm (Christiani & Nielsen) specializing in reinforced concrete design and construction, a combination which was essential if the potentiality of this material was to be tested in practice. That the designer must know not only the qualities of his materials and the way they are made, but also how they can be built into the job, was something I was soon to learn, if I did not already know it. At that time the concrete was made on the job – 'cast in situ' was the expression – and could be given any desirable shape, so here was something for the imagination to work on. I was first sent to their Hamburg office, and then transferred to London in 1923. When we reached the '30s I had had nearly 10 years' experience in reinforced concrete design and construction, mainly in marine work, bridges and industrial structures, I was chief designer in the firm's London office and had contributed to the technical press – especially a series of articles on the design of jetties. So my credentials as 'concrete specialist' were in order.

But my interest in architecture had received little nourishment. I got an introduction to visit Mies van der Rohe in Berlin in 1921, and in 1922 and 1923 in Hamburg I subscribed to progressive papers such as 'Neue Rundschau' and Wassmuth's 'Monatshefte', the latter dealing exclusively with modern architecture, visited the 'Münchener Kamenerspiele' which had moved to Hamburg to escape the reactionary atmosphere in Munich, (Adolf Hitler!) and attended most of the 'Uhraufführungen' of the plays of Ernst Toller, Fritz von Unruh and other modern authors and experienced the intellectual turmoil of the post-war period coupled with the fantastic inflation – the currency was stabilized shortly after I left at the rate of one 'goldmark' to 1,000,000,000,000 paper marks – worth about one shilling.

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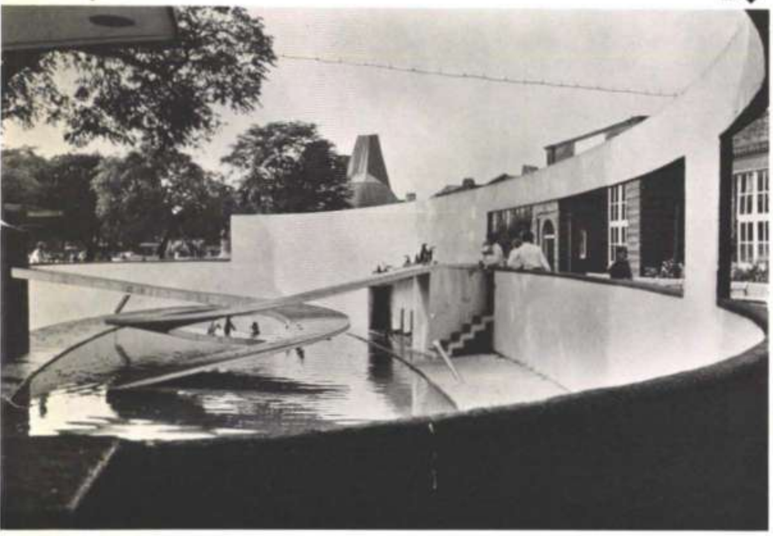

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Figs. 1-4
The Penguin Pool, London Zoo, Regents Park. Architects: Tecton

In London I had to adjust to a completely different intellectual climate – it was like stepping 50 years back in time. There were plenty of things going on in England, of course, but I was a foreigner with but a poor command of the language, and I did not happen to land in a circle where social, aesthetic or moral problems were being discussed. At that time England was even more than now split into social layers which mostly communicated with their own kind. As an engineer, I never met any architects. A year or two after I arrived in England I was happily married, lived in a studio in Battersea, cycled to the office and at lunchtime went to Battersea Park for picnic lunches with my wife. We listened to Bertrand Russell and Bernard Shaw and went to the Gate Theatre, went for walks in the countryside and punted on the Thames – all on £5 a week to begin with. And we heard Hitler on the crystal set and saw the post-war problems merging into pre-war problems.

I had plenty to do and gradually got interested and absorbed in my work and had no plans to start a new firm or anything of that sort. But I often felt frustrated, for only 10% of the schemes I produced were built, and not the best ones at that. The resistance against any kind of new idea at all was great, the bureaucratic obstructions and imbecilities were difficult to combat, and worst of all I could not complete my jobs as I wanted to because of the overriding necessity of beating our competitors on price – that was the whole idea of the game and nothing, certainly no aesthetics or dreams of 'delight', were allowed to interfere with that – they weren't even appreciated. It is not the same now, but in the sphere of private industry it was certainly the case, then.

Then in the early '30s various things happened – I am not quite sure about the chronological order: I met someone who introduced me to the Architectural Association, which I joined. I was aware that concrete was increasingly being used for building and tried to interest my firm in it. Then I was approached by Godfrey Samuel on behalf of Tecton and asked whether our firm was interested in quoting for 'Highpoint'. I was, but my firm wasn't. I wrote to the head office in Copenhagen, but they were not interested. They were not builders, they had no joinery shops or plumbers, they were making exciting new concrete structures all over the world, why should they bother with some such fiddly work? Very understandable. But by chance I was at that time approached by Kiers – Lotz & Kier at that time – who wanted to move their head office to London from Stoke-on-Trent and offered me the job of chief designer and a directorship. I agreed on condition that they would quote keenly for the work of Tecton and other modern architects. Not without serious misgivings, for it was certainly a come-down as far as structural excitement was concerned. The structural problems presented by building seemed trivial compared with what civil engineering had to offer.

Admittedly I underrated the capacity of architects to complicate the structure! But I needed in any case to cultivate the architectural 'dimension' for my own satisfaction to improve the quality of my work and I did not give up civil engineering altogether, although the move diminished my chance of getting that kind of work.

I had already helped Tecton to build the gorilla house at the Zoo while still at Christiani & Nielsen. To the consternation of the foreman the whole firm of Tecton came to help 'stirring' the wet concrete to get a feel of the material. After joining Kiers I worked with Tecton on the Penguin Pool and on Highpoint. Lubetkin was delighted when I suggested leaving out the columns and most of the beams and allowing the walls to take over the work of columns and lintels. This was both simpler to do and neater and was in line with what I had been doing for industrial structures, coal bunkers and silos. I had realised earlier that the reinforced concrete slab was a much underrated structural member. It was always considered as a panel which had to be supported by beams or columns at the edges, whereas in fact it was very strong in its own plane and able to resist forces in that plane. Used as a wall it could take vertical loads and span over openings. Because of the simplicity of the formwork I considered the slab to be the natural element for reinforced concrete. This view had already been put forward by Maillart, but I had never heard of him. It also influenced Tecton's design for the Penguin Pool at the Zoo. Another advantage of designing the structure as a simple box was that it would make it possible to rationalize the formwork, using the same set of wall forms for the whole building by inventing a way of lifting the forms up from bottom to top in a series of steps, three to each floor. Nowadays one would only use one lift per floor, but at that time one was not allowed to concrete more than 3ft 6in. at a time to ensure proper tamping of the concrete. Another of those completely unnecessary restrictions!

That the design must include designing or specifying the way of building was one of the useful lessons I learned at C & N, a lesson which I have tried to preach to all and sundry with severely limited success.

That what we may call sculptural simplicity mostly favours constructional simplicity is, however, not the only reason for pursuing it.

Figs. 5-7
Dudley Zoo.
Architects: Tecton
(Photos: A. F. Kersting)

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For me simplicity has always been an aim in its own right, presumably because it is allied to clarity and architectural quality. But neither sculptural nor constructional simplicity can be identified with structural simplicity. The visual simplicity is often deceptive; it can conceal a pretty contorted structure resulting in high stresses and an unhealthy concentration of steel reinforcements at critical points. The internal stresses produced by outer forces and temperature movements may revolt against being constrained by an artificially imposed spacial straitjacket. And it was very difficult to get unusual, so-called 'special' structures which did not conform to LCC regulations passed by the authorities. These regulations only covered the normal orthogonal grid and if Highpoint had not been situated in Hornsey, which was outside the LCC area, it could never have been built in that form.

Unfortunately most of my designs were of that special kind so I had a running battle with authorities and didn't always win.

To my surprise the Highpoint structure was later hailed as a great innovation, largely through Lubetkin's flair for publicity, and he bestowed on me the name of 'doctor' – a name by which I am still known to some people. It did not help that later I sent a notice to *The Architects' Journal* promising a reward of £500 – or was it £50? – to anyone who could prove that I was a doctor.

Anyhow, through Lubetkin's help I acquired a kind of reputation among modern architects. It was not far from being hinted that I had practically invented reinforced concrete. Which shows on what flimsy ground reputations are built.

As I mentioned before, Lubetkin welcomed my proposal to do away with columns and beams, and then, typically, as I was to discover, proceeded to make it almost impossible for me to do so. I had started my first lesson in architecture!

It is well known that the aims of the dyed-in-the-wool architect are not always the same as the ditto engineer. There is obviously something wrong with the dyes; they clash. They must be harmonized. It is easy to demonstrate the nature of these clashes in a simple case like Highpoint, and it may be useful to do so, even if this kind of construction is now obsolete.

'Gimmicky' ornament

That the block of flats had to be put on columns à la Corbusier was a purely architectural device. It would be difficult to pretend that it is useful in this case, it would be much simpler to start the whole apparatus for lifting the formwork at ground level. And as the vertical forces are taken to the ground through the outer walls, it would have been simpler, if there had to be columns, to place them in the line of the external wall instead of pushing them inwards to a position which pleased the eye rather than the physical facts. Transferring the whole weight of the building horizontally creates considerable moments, necessitating crossbeams which again have to be concealed, etc.; this causes a fair amount of trouble and expense. But it could be done fairly easily, and the architects of course wanted it done, and when I visualized the building without this and other architectural 'gimmicks' – an expression which engineers often apply to architectural expression – I could easily see that they were right.

The same applies to the small balconies on the end elevation. They are not really made for use or easy construction, they are ornaments, 'gimmicky', but highly successful, in my opinion. Ornaments were supposed to be out, of course. They had to have a functional or economical excuse for their existence, and architects have developed a great flair for producing such excuses out of thin air for clients who would not take kindly to 'aesthetic' reasons. In this case the balconies could be fire escapes. Not a bad excuse, actually.

Matters get worse when we come to the large window openings in the living room of the larger flats. These cut away most of the wall on this side leaving only wall strips on each side to take the vertical load. Coinciding with this opening there is a balcony cantilevered out from the floor slab with a heavy balustrade and no sidewalls to support it. The weight of the floor and balcony has to be transferred to the vertical wall strips by the panel wall under the window acting as a horizontal beam, which it can just do by thickening it and adding steel reinforcement. But then comes the final blow – this panel has to be cut away on one side to give way for the door to the balcony, so that it never reaches the supporting wall on this side. The floor is the only connection.

There is no satisfactory solution to this structural problem. However, reinforced concrete cast in situ is a very adaptable material. The structure forms one monolithic whole, where a stress or strain in any part can be felt in every other part. If one point is in danger of being overstressed, other parts can be persuaded to come to its rescue by suitable reinforcement. In this case the floor can be cross-reinforced to spread the shear and moment sideways over a wide area of floor and balcony, the remaining panel wall can be cantilevered from the column strip on the other side, etc. It's a muddy kind of structure, one doesn't know exactly how the stresses are distributed, but one can ensure that the structure is perfectly safe, although it probably would not comply with the regulations. Not at that time, anyhow.

All this could have been avoided if we had provided a narrow vertical wall support between the door opening and the window, but this would have interrupted the horizontal sweep of the view.

Was it worth it? It's a moot point. I didn't like this kind of contorted structure. The architects didn't mind. They had got what they wanted, it couldn't be seen, nobody would know about it, it wasn't their money. Should the client have been consulted? He rarely is, in such cases. The architect takes it upon himself to act for the client. Which, it can be said, is what he is supposed to do. What does the client know about architecture? He might make the wrong decision. The engineer should not be asked; his job is to keep mum. He has an easy way out, of course. He can simply say that it can't be done, or that the architect must take the full responsibility. That would put an end to it. But it wouldn't be true. It can be done. It's safe enough. I certainly wouldn't like to take this line. And I honestly do not know what the answer should have been in this case. I can see the architect's point of view. If I had been the client I might well have agreed with him.

'Strong' architects

I have described this case in detail because it so simply highlights the kinds of problem which keep occurring in architect-engineer collaboration. On the work we did for Tecton there are many such cases, and it is the same with any 'strong' architect, who has a very definite opinion about where he wants to go. They are, in fact, the kind of architects I like to work with, in spite of the extra effort required. I don't think much of those who say that I should decide on an appropriate structure for the job and they will fit their architecture to it, and I have met a few of those, especially in the early days of functionalism, when the functionally 'right' thing was supposed to produce the right architecture. It doesn't, it produces no architecture at all.

In those days I got quite a reputation for doing tricks with reinforced concrete. It was even assumed by some that I liked doing it. That was entirely wrong. Simplicity is what I have always been striving for. A tortuous structure is not an architectural asset – it is a flaw in the total architecture. It is a potentially weak point in the structure.

Try, try again

I owe a great debt to Lubetkin and Tecton. They taught me that architecture can only be produced by trying again and again until a satisfactory solution has been reached, and that the engineer, bent on creating logical, elegant and buildable structure, must realise that there are other more important aims which may take precedence, even at the cost of a distorted and more expensive structure. The architect, on the other hand, must realize that the engineer's aim is important and should not be jeopardized for a mere whim, and that there may be a case for a fresh look if it can't be achieved with the present arrangement. Engineers may complain that this the architect is not willing to do because it requires more effort and he is not really interested in the structure or even the cost as long as he gets what he wants. And the architect may complain that the engineer doesn't try hard enough to meet his requirements.

Getting to know a group of architects concerned about the fundamentals of architecture and joining MARS meant much to me. It was like entering a new world, there was a complete change of atmosphere. Here was a group of people with a sense of mission, a common cause: to create a new architecture which would cast off the tyranny of 'Beaux Art' and all the old styles for all time and replace it with a new international style based on our new technology, which was capable of satisfying the needs and aspirations of mankind if used with reason and justice. Or words to that effect. The cause was never very clearly defined, but the enthusiasm was there, there were debates on social and technical problems, on ends and means, there were arguments and strife. In short, there was life. There was the feeling of 'Brüderschaft' which had received a message from on high and had a duty to convert the world, and there were individuals who followed their own line which was then adopted as approved 'modern' although it looked a bit odd in the context. What, for instance, had Corbusier and Frank Lloyd Wright in common?

I agreed with the need to sweep away old cobwebs and start afresh. 'Functionalism' to me meant that the buildings we build should fulfil their function – priority number one – and that materials should be used in accordance with their physical properties and the way they are manufactured and placed in the final fabric of the building. But I soon found that that was not the general opinion – or not the general practice at any rate. In most cases priority number one seemed to be that the building should look 'modern', like a building by Corb or Mies or some of the other masters.

'Modern Style' – 1935 report

I am tempted to quote from a report of 11 April 1935 sent by the MARS exhibition committee (Sise, McGrath, Drake) to the executive committee. Although it was fortunately rejected by the latter, it was a very typical interpretation of the 'Modern Style'. After some paragraphs about the exhibition, etc., there is one on 'General considerations':

'The attitude it is proposed to adopt is as follows: There exists throughout the world today a manner of building which "orders the visible manifestation of a certain close relationship between structure and function".

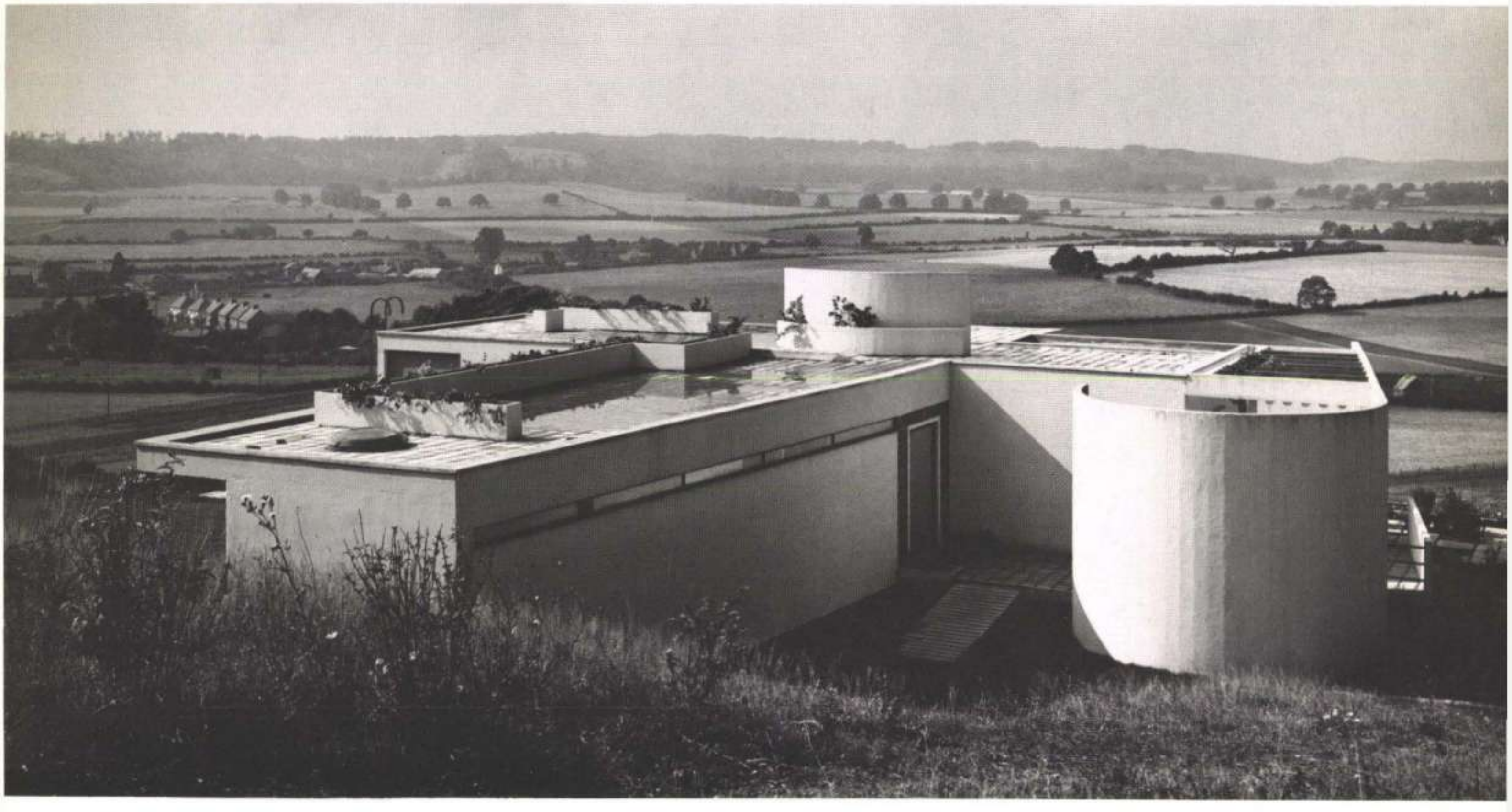

Fig. 8
Cottage for Berthold Lubetkin, Chiltern Hills.
Architects: Lubetkin & Tecton
(Photo: Dell and Wainwright)

This healthy situation – the life-force of so many historical styles – has been brought about in our day by a deliberate and self-conscious application of the logic of modern constructional methods employing, for the most part, steel and reinforced concrete, to the solution of a purely objective analysis of modern needs.'

and later on 'Morphology':

'It would seem that a style is born of the marriage of structural with functional forthrightness. The forms which result are found to be pleasing for their own sake and introduce into the mind of the designer certain considerations or principles which guide him in the realm of pure design after the needs of structure and function have been fulfilled. The stressing of these aspects for their own sake without prejudice to structure or function marks the period of maturity. The period of decadence has been defined as the time of stressing or distorting certain characteristics to a degree of perversity. In any case we are not here concerned with decadence. It must be suggested, however, that the beginning of the period of maturity has been reached though there is undoubtedly a wealth of development ahead. These distinctions, however suspect they may be in some respects, are useful to us in forming categories of the various subjects to be described in the exhibition and for explaining those values which are beyond pure structure or pure functionalism.'

The new style is then described under four headings:

1 Characteristics

(1) Steel and reinforced concrete for structural members

(2) Glass, insulators and plastics as sheathing materials

(3) Frame construction with non-bearing walls as the norm

(4) Variations, using bearing or part-bearing walls

(5) Typical span-proportion of steel and reinforced concrete – the result of economic forces restricting the very wide structural possibilities of the material

(6) The characteristic proportion – module which results and which tends to give a horizontal emphasis to the essential anatomy of the structure and which, if honestly expressed in the façades, gives a horizontal emphasis to the outside appearance of the building

(7) The possible wide openings of all kinds

(8) The cantilever

(9) The hung wall

(10) The resultant possibility of continuous horizontal windows

(11) The use of balconies, flat roofs and roof terraces

(12) Freedom of planning due to frame construction

(13) The use of 'pilotis'.

(14) The standardisation of parts

(15) The frequent use and aesthetic validity of machinery as an integral part of the building

(16) Detail, gadgets, lighting fixtures, etc., supplying decorative 'spots of emphasis'.

(17) The use of sculpture in the round, mural painting and mural photographs for decoration.

2 Principles

(1) Functionalism as a state of health – a discipline

(2) The wall as an enclosing shell – which derives from the non-bearing wall of frame construction

(3) The feeling of 'surface tension' which such a wall should have – achieved by keeping projections to a minimum and by placing glass as close to the face of the wall as possible

(4) 'Architecture as volume' as opposed to the conception of 'architecture as mass' which applies to most historical styles

(5) Clear articulation of form and function

(6) Maximum simplicity – the preservation of the bounding edges of large geometric forms

(7) Building to be light and effortless. Should almost have appearance of floating – of being poised, like a soap-bubble

(8) Classic repose – no dramatic effects of movement

(9) The flat roof – for lightness and to preserve clear geometric forms

(10) The principle of regularity. The aesthetic validity of standardization. Use of the repeat of some structural proportion of standardized feature such as a window which can bind dissimilar elements together in the same way that the stressed tempo binds together contrapuntal music

(11) The use of new synthetic materials for their own sake and in general, the honest use of all suitable materials

(12) The avoidance of brick or anything giving an ashlar effect for wall surfacing as these give an effect of weight

(13) The scientific and sociological approach to all new problems

(14) The use of white and light tones both to add to the effect of weightlessness and to secure maximum of relected light.

3 Negative principles

(1) No conscious striving for symbolism of function

(2) Avoidance of axial symmetry which was an historic device for binding together dissimilar elements having no horizontal emphasis. It is seldom functionally justifiable and in these days merely looks pretentious

(3) Avoidance of applied architectural ornament.

Historically we must go through a period of discipline and let ornament grow naturally – probably out of gadgets – at the moment it is distasteful as it tends to give effect of weight and to break up surfaces of clean cut geometric volumes.

(4) Avoidance of stressing any 'movement' in the design not honestly derived from the nature of the structure.

4 Considerations

(1) Our central aesthetic credo: That the essential qualities of a work of art lie in the relationship of form to form and of colour to colour. From these the eye, and especially the trained eye, derives its pleasure and all emotion in art must be transmitted through these means.

(2) Internationalism. Why the style is international, etc., etc.

(3) The search for the 'norm'

(4) Avoidance of stressing any 'movement' in the design achieved by the spectator if he is to understand and enjoy the style.

Obviously there is much to baulk at in this summary. As I said before, I had my misgivings. If the study of philosophy had taught me anything, it was to distrust all ideologies, all all-embracing systems, all belief that human affairs can be explained or governed by logic alone. I did not know enough about architecture to express an opinion about architectural style – so on that theme I kept a low profile, as the saying goes. As an engineer I was really a second-class citizen in this context, a fact which I fully accepted. I could be useful, a good midwife in assisting the birth of a new architectural creation, but I was not responsible for the architecture and what we were talking about was the birth of a new architecture. That I had my preference is another matter; I was enthusiastic about some modern buildings and some left me cold, and as time went on it seemed to me that the best got better and the bad got worse and more numerous.

In 1935 Lubetkin and Tecton (and I) won the first prize in a competition for 'working men's flats' sponsored by the Cement Marketing Co., and with the prize money Tecton and I with our wives went to France to see some of the work of Le Corbusier. The Pavillon Suisse was the first I saw, and it really made a deep impression on me. I also admired the Villa at Garches – although I was not sure I would like to live in it, it was too cold and too public, one would have to be very careful about how to choose and place the furniture, it was an exhibition more than a home, and it obviously would not weather well; the steel was already beginning to rust and the concrete had lost its pristine whiteness. The Salvation Army home for old people did not appeal to me at all, but that may have been because of the foul air inside caused by malfunctioning airconditioning – one of the much-praised innovations. I was glad to get out.

Back in London I worked with Wells Coates, Goldfinger, Mardall (then called Sjøstrøm), Kaufman (who won an 'honourable mention, in the Cement Marketing competition), Entwistle and others on a number of schemes – but it was all a labour of love – no building resulted.

Some were published in some articles I wrote for *Architectural Design and Construction* about how to design reinforced concrete structures for buildings, which I hoped would teach architects some basic facts, and also to attract customers, of course. Others were published in *Boxframe Construction*, one of several publications I issued to all and sundry, the later ones dealing mostly with air-raid shelters, a chapter by itself which ought to be told one day as an example of how not to do things.

'Research' – a misnomer

To MARS I contributed a number of papers and took part in the work of committees. I have counted up to 17 such committees over a certain period. My first paper made it clear that Modern Architectural 'Research' Group was a misnomer, for a dozen or so young architects working a few hours at weekends cannot do scientific research into soundproofing, thermal insulation, etc., without the necessary apparatus and technical expertise. But my proposal to establish architectural research instead met with the probably valid objection that a group of architectural personalities could never be expected to agree on what was the best architectural solution to a problem.

The CIAM Conferences provided a unique opportunity to meet interesting people from all over the world in beautiful surroundings, people who were devoted to architecture, many of them great artists and personalities in their own right, and who, therefore, had some difficulty in agreeing on very much, which led to stimulating discussions. But I did not think much of the manifesto issued at the end which tried to extract some general principles from the welter of discussions. Generality leads often to banality, but to see the work of other groups and have it explained and discussed was certainly useful.

I remember working very hard in a little restaurant in the mountains as a member of 'comité quatre' dealing with structure in architecture under Wells Coates' chairmanship, trying to produce a summary of our week's deliberations. A French engineer, whose name at the moment I have forgotten,

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but who worked for Corb and was a man of some importance, insisted on pushing a super logical and categorical declaration to which Wells and I could not agree. We ended up with a completely banal document which was of no value at all and was never referred to later by anybody – in spite of, or perhaps because of – Wells' considerable skill in manipulating committees. A beautiful afternoon wasted, not for the first or last time.

The work on the MARS exhibition was not wasted, however. That was a really great achievement. I was the 'treasurer' at that time, a job nobody else wanted but which was thought to be suitable for an engineer. I was in fact extremely unsuited for that work, and had no control whatsoever over what Entwistle, Wells and the others spent on the various sections which they designed. They just ordered the general contractors to do this and change that, and we ended up with an enormous deficit and then went to industry begging to be bailed out. But it was not enough; in the end the executive committee had to fork out – Max Fry made a great contribution, I remember. He was always one of the most enthusiastic. But that exhibition really made an impact. It showed the sunny side of modern architecture – but it was probably too good to be entirely true.

Another important contribution by MARS was the 'London Plan', but that came later It was the work mainly of Arthur Korn and Felix Samuely. By that time I was so busy with my own 'shelter' war that I had no time to participate.

The shady side of the Modern Movement was for me represented by the previously quoted 'Modern Style' document. It appalled me, it wasn't functionalism at all, how could the various injunctions be justified in terms of function? But I must make it clear again that it was not the view of the MARS executive committee or most MARS members.

The followers of fashion

It was more the followers, those who caught the fashion but didn't quite know what to do with it, who caused the quality to deteriorate. If we turn to another contemporary document, the booklet produced for the MARS Exhibition in 1938, we get quite a different picture. There is an extravagant foreword by Bernard Shaw and a very mature and sensible introduction which actually attacks the idea of a new style. I should like to quote it in full, but here are a few sentences:

'The architect who is committed, at the outset, to thinking in terms of a style – that is, of an idiom which is already crystallised and inflexible – is hopelessly shackled.'

'Modern architecture is not based on the crude assumption that whatever functions best is right. Such an assumption is in any case, meaningless. Architectural design cannot, except in the very simplest cases, be mathematically controlled; it is an affair of infinite adjustment, and unity can only be achieved by sure intuitive judgment on the part of the architect. Calculated structure – i.e. engineering – is only one component in the synthesis which we call Architecture.'

This makes sense. But for me there was still something phoney about the whole business. It was a strange situation. Here was a group of people with a romantic attachment to science and technology, to new materials, steel, glass, lightness, air, elegance, speed and power – it was beautiful, it could solve all our problems, bring peace, justice and happiness. One would have thought that they were the

Figs. 9-11
Rear views of Highpoint 1, Highgate, London.
Architects: Lubetkin & Tecton
(Photos: John Donat)

scientists, engineers and manufacturers who knew what these materials and scientific methods could do for us, who understood their great potentialities, who were enamoured with the world they themselves had created. Not a bit of it. Engineers and scientists had no part in it.

They were admired at a distance. The people who instigated the movement knew next to nothing about science or engineering construction; they were visionaries, artists, social reformers who had never calculated or constructed anything, and followers who were enraptured by the vision. To explain this one must, I think, go back to the time when architects ceased to be 'master builders'.

I am not thinking of the Middle Ages, but to the time they ceased to know the nature of their materials and how they were used in building. Turning architecture into a genteel occupation concerned with styles, proportion, grandeur, poetry or what have you, and leaving building to builders, paved the way. But the real body-blow to 'master building' was delivered by the new materials and technology introduced by the industrial revolution. The reaction of architects to this development was the one natural for them – it enabled them to design differently, to make longer spans, to imitate forms and images used by engineers whose achievements were much admired, or by the new movements in the visual arts. I do not want to pontificate about architectural history – I may be wrong – my point is that they did not think it necessary to learn how to build differently; for them designing and building were two different domains. They are not. A design should show how to build so as to fulfil the purpose of building in the best way, or to the greatest extent, and this cannot be done without knowing how to build.

Architects and facts

It is as if there is a streak of dishonesty running through the architectural profession. They do not face facts, they fake facts.

This is a serious accusation and, of course, it cannot be applied generally, and leaves much out. But the tendency is there. I have been consulted by architects presenting finished designs, but who hadn't yet decided what materials to use – reinforced concrete, aluminium or plastic. And those who design in brick with concrete lintels, plaster the whole thing and paint it white to make it look like a building by Connell Ward & Lucas, and I could mention many more such examples. I will not talk about the hiring of specialists who make attractive perspectives to confuse prospective clients, or those who enter competitions with striking designs or soaring arches or whatever which could not possibly be built in that form – it may still show whether they are good architects. And then there are the Archigram type of fancies – what are they for? A look into the future? A better way of living? A possible way of building? None of these. I can enjoy Heath Robinson, etc., but Archigram isn't all that funny. But all this is comparatively harmless. It is when their lack of knowledge is allowed to penetrate into their buildings that the harm is done and their reputation is impaired. Perhaps they think it is enough to employ a quantity surveyor. I have nothing against quantity surveyors personally and in many cases they are the most useful members of the design team in the present circumstances. But as I have preached in lectures and articles for 40 years – I am convinced that the whole system as used only in the British Commonwealth is wrong. Costing should be an integral part of designing. It is no use finishing the detail drawings, compiling an absurdly detailed bill of quantities, serving the legal purpose of tying the contractor to an adjustable contract, pricing it without knowing what method of construction is to be used or what the local conditions are – and then finding that the cost is too high and that something must be chopped off. It's wasteful in every way. Costing must act as a check on designing. If something is wrong it is not cured by more

Figs. 12-14
The Foyer at Highpoint 1
(Photos: John Donat)

Fig. 15
Entrance of Highpoint 2, Highgate.
Architects: Lubetkin & Tecton

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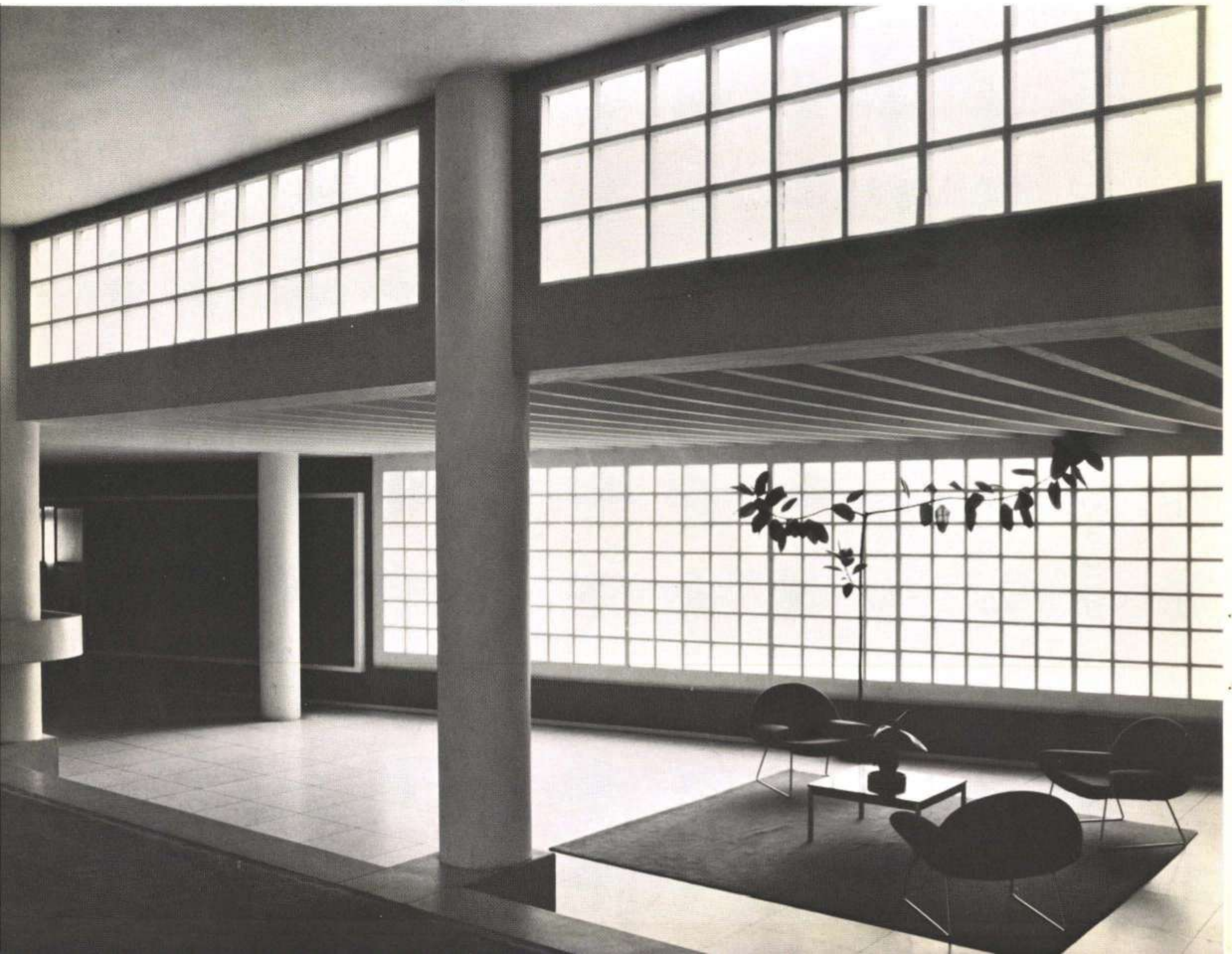

costing but by better design. What we need are quality purveyors.

But the system is flourishing – presumably because clients have much more faith in people who are supposed to understand money matters. I know I am sticking my neck out – and may I say here that all I say is off my own bat – but I have done that for 40 years and there is a perfect way of dealing with this sort of thing. Cotton wool! Complete silence and smothering kindness. Engineers have been taught to deal with the forces of nature. You cannot defy the forces of nature. Therefore they have to face facts, and if they know their job, they do. In that respect they have their professional integrity, they are not tempted to cheat.

Architects are dealing with human beings. Human beings are unpredictable, fickle, but also easily bamboozled. But what's wrong with engineers is that they only deal with facts which can be weighed and measured, and simply ignore the others, the intangible, the dreams and visions, delight and despair – all the most important things, in fact. Of course, this again must be taken with more than a grain of salt – I am dealing with caricatures – but they reveal something of the characters of architects and engineers. What we need is a combination of the integrity of the engineer with the vision, sense of beauty and human understanding of the architect. A good architect, that is. Only a few can do the whole thing alone these days, unless it is a very simple job.

But even this may not be enough. Our technology has moved so fast that even engineers don't know how to build. They are specialists. We don't build in the old sense. What happens on the site is pre-ordained, a large technical apparatus takes over. It's in the factories that things really happen and each branch of manufacture contains a world of technical expertise. The capital invested exercises a tyrannical compulsion, innovations cost time and money, inconvenient improvements are suppressed. Computers and machines take command, if used to make things easier instead of better.

Engineers will still be needed, if they toe the line. But will we need architects? My opinion is that we need what architecture stands for, or should stand for, more than ever. Humanity must win the battle for control. But it will be difficult. Architects need to face the facts of our industrial society – which was in fact the theme of the modern movement. But not by just 'designing' according to their fancy, but by understanding how things are made in our age and in the relevant locality. Their 'design' must be a part of a 'total' design which takes in all the design decisions which are needed for the job. And it must take notice of the repercussions the design has in other spheres, it must be comprehensive, or must at least try to be.

I am on my old hobby horse, teamwork and all that. I am aware that I do not know how to cope with the complexities of the modern world and have nothing to contribute to design in present circumstances, although I may have an inkling of what design is about. When you think of how the enormously complicated and interwoven technical apparatus, allied with the power of high finance, functions according to its own inexorable laws, is there not a danger that it will end up controlling our life? And if we interfere, the complicated nature of the beast will require an enormous bureaucracy which will create havoc and destroy the efficiency of the system. Of course, the problem could be solved, but can we solve it? Are we good enough? But people are changing too. Some like excessive noise, 'happenings' in quick succession, speed, excitement. Some like to be told what to do, others are a law unto themselves. Some like to love, some like to hate. The ingredients in the human cauldron are too numerous to count. I only hope that we need not all become robots to fit in. Although – if that's what people like – why should I?

Editor's note

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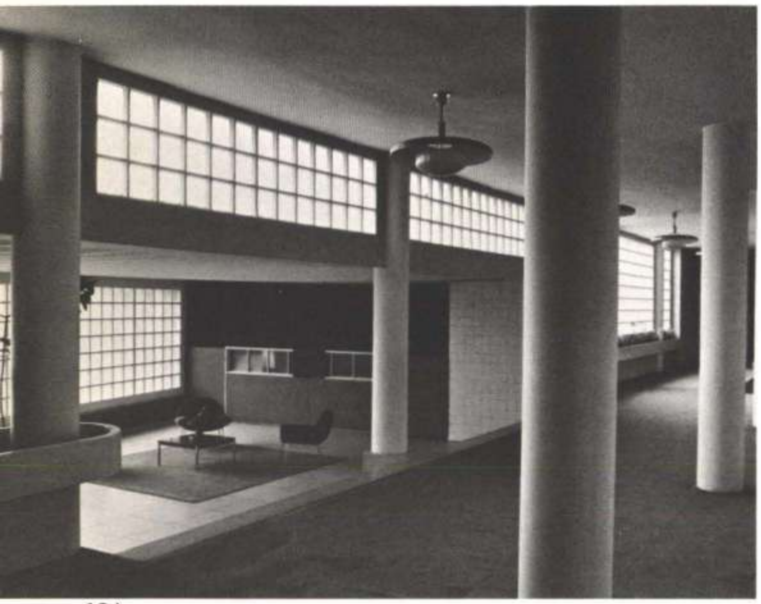

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The development of desk top computers in the Ove Arup Partnership

Robin Whittle

The first desk top programmable calculator was purchased by Arups in 1969 for use in our Research and Development Group. The need for it arose because a number of design tables for reinforced concrete structural elements were currently being prepared. Some use had been made of the in-house computer, an Elliott 4100 as it was then. However it had proved a slow and wasteful process to set up programs which contained complicated logic just to produce a set of tables.

There were not many 'desk tops' on the market at that time. The Olivetti 101 had been around for a few years but was noisy and tricky to use. The then computer manager suggested trying out a new machine which had just appeared on the market. This was the Hewlett Packard 9100A (see Fig. 1). This had immediate appeal and appeared to be superior to the Olivetti in many ways. It was quiet, displayed the numbers typed and used the simple 'reverse polish' logic, which is still the basis of all their pocket calculators of today. Programs were stored on small magnetic cards. A printer was sold as an optional extra which fitted on top of the calculator.

It was agreed to purchase one machine without a printer and very soon this was earning its keep producing the numbers for design tables and charts. It was also becoming useful for helping engineers with simple but lengthy calculations which could be extremely monotonous to do by hand. Enough facilities were available to set up primitive iterative programs. Probably the most well-known of these was the section properties program which allowed the user to enter as many points as he wished and which catered for holes and any shapes. This was achieved in 138 program steps using all six stores. Fig. 2 shows a typical sequence of entering points.

Interest in this machine rapidly spread and in 1970 two further 9100Bs were purchased for Arups' UK practice. One went to the Roads Group in London where a number of programs were set up to calculate geometric parameters for road intersections and curve fitting. The other went to Arups' Edinburgh office where production programs were developed. The results of these were printed onto 60mm-wide strips which could be stuck on to preprinted A4 sheets to provide part of the final calculations. Both these machines had printers and twice the memory capacity of the original 9100A. In addition the Edinburgh office machine had an extended memory unit provided in a separate box.

One remarkable aspect of these three machines is that they are all being used as much as ever, 10 years later. They have required very little maintenance and have incurred less than £500 repair charges *in toto* since their purchase.

A strong effort was made early on to maintain a discipline with regard to the documentation of much-used programs. The main headings for this were summarized as:

- Reference number and name of program
- Function
- Method of solution
- Outline flow chart
- User instructions
- Example
- Program listing

At about the same time another 9100B was purchased for Arups' Sydney Office. Documentation of existing programs was exchanged between all Arup offices with machines but there is little evidence that much use was made of this. The number of people who actually used the machines was limited to those who worked close to them. They were generally enthusiasts who were quite capable of writing their own programs quickly and using just those.

A significant change in 'desk tops' occurred when Hewlett Packard announced the arrival of a new model, the 9810 (see Fig. 3). This had many similarities with the 9100 series but contained a much larger memory and an in-built thermal printer. The latter was still only 60mm wide but it did allow text to be printed as well as numbers. Longer magnetic cards were provided on which to store programs. One of the design groups made the decision to purchase one of these and three months were spent on the writing of a suite of structural production programs which were available for use when the machine arrived. These programs very soon became widely used within that group and provided many engineers with their first experience of positive help from a computer.

The next two significant changes in the 'desk top' development followed on very closely after the appearance of the 9810. Almost as soon as it had been installed, two new machines were announced; the 9820 and 9830 (see Figs. 4 and 5). The 9820 had one striking advantage over the 9810; this was a complete change in the way it displayed and manipulated information. Instead of the 'reverse polish' method of entering and operating on numbers, the user was able to type in the expression directly and press the execution button for the answer. The following is an example of what could appear on the screen.

$1350 (300 \times 7.5 + 4500) \uparrow 2/787500-25000$ as typed

53107.14 appeared on the screen after pressing the execution button.

Other advantages of this machine lay in its simple and quick program editing facilities.

These features were so attractive to those who witnessed a demonstration that the Partners were soon persuaded to purchase one machine immediately for another design group with six more to follow. The first was received with enormous enthusiasm. Several engineers spent much of their spare time setting up a comprehensive suite of programs. For the first time a rectangular reinforced concrete column section analysis program become available. This gave results for a particular combination of load and bending moments.

Four of the further six 9820s went to London. The two other machines went to the Birmingham and Newcastle offices. The policy for developing and documenting programs was complicated by the aim to encourage engineers to become more familiar with computers both from using programs and from developing them. This led to some duplication of programs and, in order to reduce confusion, an overall index of programs was produced. Each was labelled with a category to indicate the level of documentation and reliability. It recognized the reference given to each program by the originator but also provided an overall numbering system.

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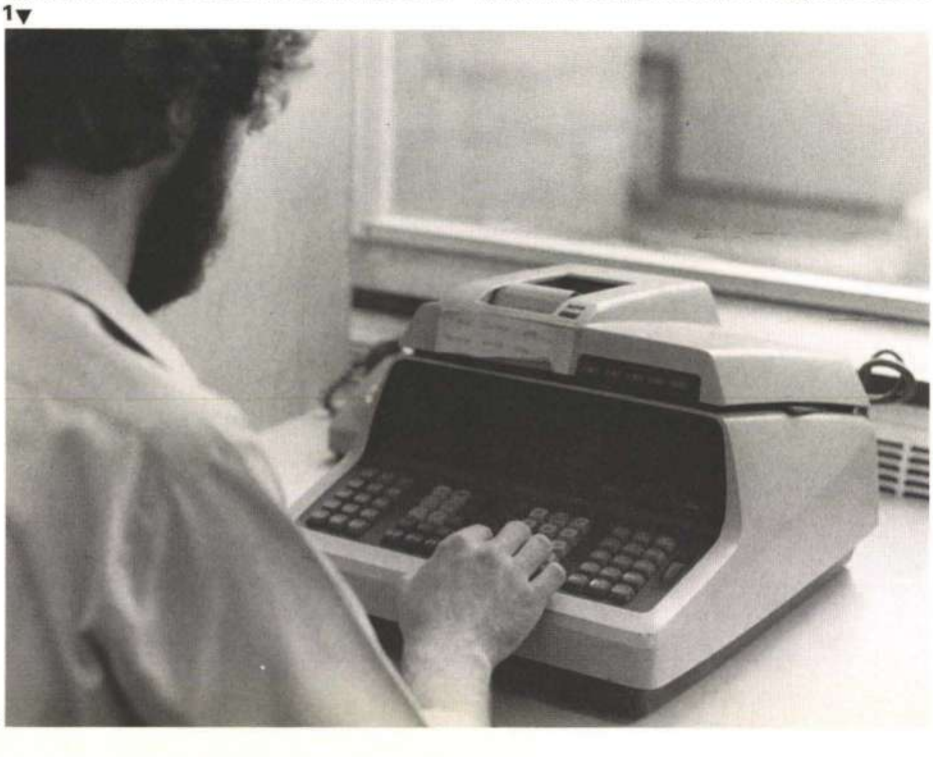
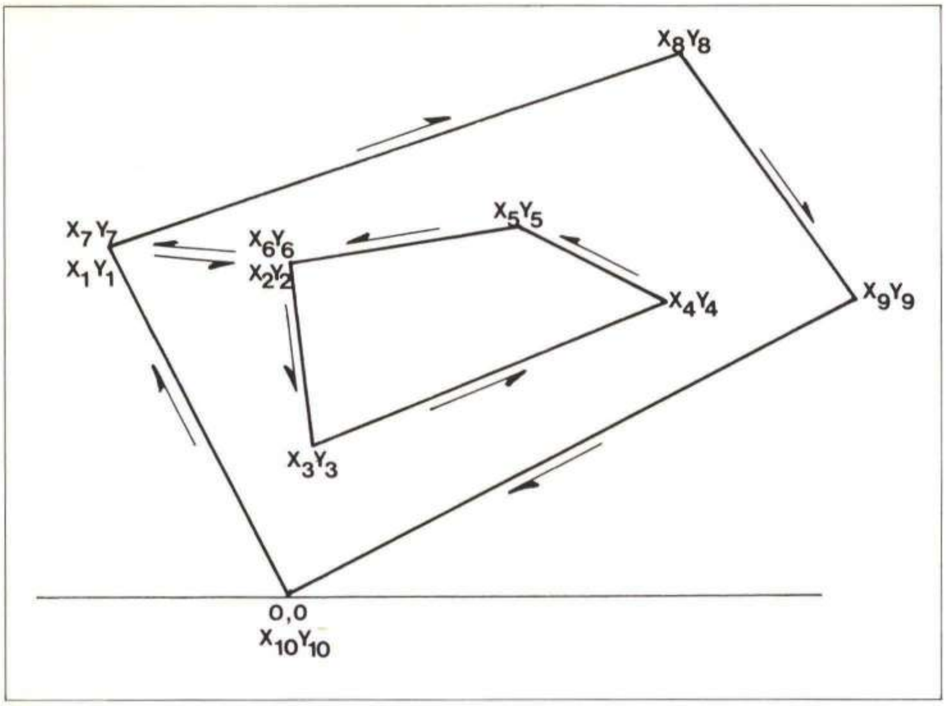


Fig. 1
Hewlett Packard 9100
(Photo: Poul Beckmann)

Fig. 2
Section properties program

Fig. 3
Hewlett Packard 9810
(Photo: Poul Beckmann)

Fig. 4
Hewlett Packard 9820
(Photo: Poul Beckmann)



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One of the London 9820s was allocated to the Research and Development Group and the original 9100A was passed from there to the Glasgow office. R & D was asked to develop further production programs, either by extending existing partially documented ones or by starting afresh if a need was clearly expressed. Two of these acquired considerable significance some years later. The first was known as BIABEND, an analysis program for irregular reinforced concrete sections. This was transferred to the larger desk top 9830 and extended to include prestressing. It was then used to check hundreds of different precast composite sections during the nationwide check of beams made with high alumina cement.

The other was a program for the analysis of reinforced concrete sections. This was used in 1976 by the Design Office Consortium to check results from seven continuous beam programs developed by different organizations for which a comparison report was being written.

Program development

Even in 1973 the continuous beam analysis program was the most popular of programs for the 9820. R & D developed one for uniformly distributed loads which was then extended to cope with flat slab analysis. A year later a more advanced program was developed which catered for point and variable intensity loads. Although documentation of this was never completed it became widely used, and formed the basis of the GLADYS beam program developed for the DEC 10 computer in 1975.

Two further 9820s were purchased for the practice, one for Malaysia and the other for Melbourne in Australia. Copies of programs were interchanged between offices on request and this proved much more worthwhile than the earlier interchange of programs for the 9100 series.

In 1972, whilst the development of 9820 programs was still under way in London, four 9830s (see Fig. 5) were purchased for regional and overseas offices. These went to Manchester, Edinburgh, Cardiff and Dublin. The 9830 had little in common with the 9820 apart from a wide screen which could display long algebraic expressions, text or single lines of programs. The memory size, 16K bytes, was much larger and this led to the use of a more formal language, Basic. Magnetic cards used for the storage media on the 9820 were no longer appropriate and magnetic tape cassettes were used instead. Each machine was supplied with an A4 width thermal printer and an A3 size plotter. These enabled the user to obtain results which could be filed directly with his final calculations.

Regional contributions

Manchester and Dublin offices made the largest contributions to development. Manchester's continuous beam analysis program was the most popular program in use. This gave bending moment and shear envelopes drawn on the plotter for beams with variable section properties and any load combinations. Plane frame and truss programs were the first of a suite developed in Dublin. They were followed by grillage analysis and space truss analysis. A great deal of effort was spent on these programs to provide the correct level of interactive language. The users found them easy to use and did not have to keep referring to user manuals.

Soon after the regional offices had acquired 9830s, a committee was set up to discuss and organize the development of programs. This met two or three times a year and included Arups' Computer Group manager and myself. Manchester became the centre and held the master copies of most of the programs and user manuals. It also took on the duties of issuing updated versions of the programs to

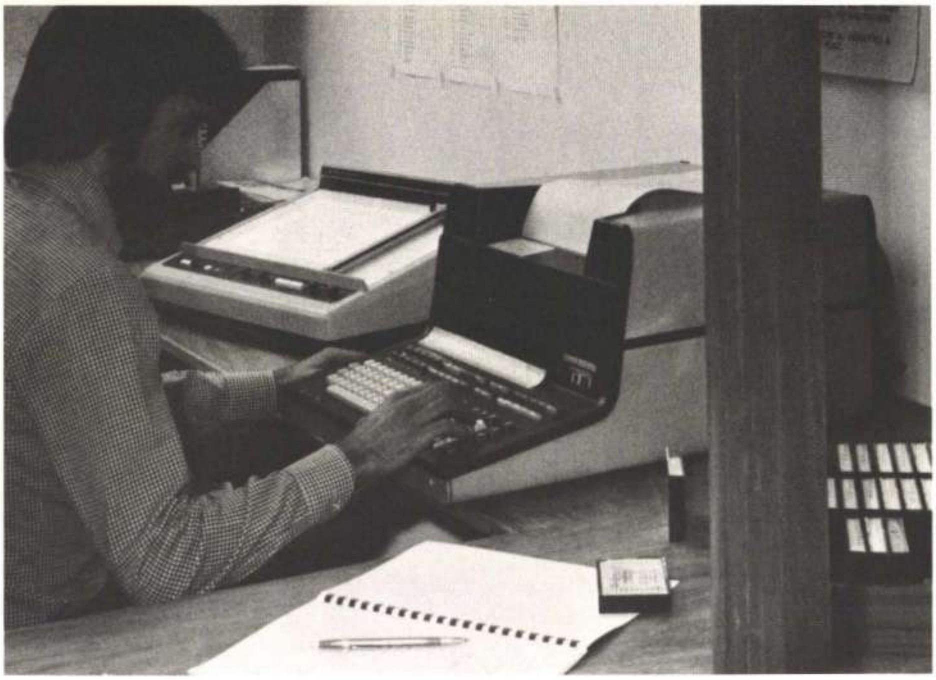

Fig. 5▲
Hewlett Packard 9830
(Photo: Malcolm Jordan)

Fig. 6▼
Hewlett Packard 9845
(Photo: Poul Beckmann)

all the offices with 9830s. This task increased as more 9830s were later purchased in different parts of the world.

The first of these new machines arrived in R & D in 1973 with a request to help with the development of programs for the regions. This commenced with a number of programs which would help with the use of the then recently published *CP 110*, Code of Practice for the structural use of concrete. The first of these was for the design of reinforcement for continuous beams and developed to connect up with the continuous beam analysis program. Others which followed included programs for rectangular column analysis and design, beam deflection, shear in flat slabs and irregular column section analysis. Some of these programs were produced before the importance of properly formatted results sheets was fully realized and suffered from the lack of consistent paging layouts. However the logical development towards this end had begun when the London office began preparing programs to run on the new DEC 10 computer installed at the end of 1975.

It was somewhat unfortunate that more advantage was not taken of the program development work on the 'desk tops' in spite of much correspondence and reports, such as AIDS, written to promote this course of action. The development of the 'desk top' programs was considered to be not sufficiently advanced and this, combined with the problems of translating from Basic to Fortran languages, pushed the decision in favour of a fresh start. This culminated in the start of development of the GLADYS suite of programs.

In early 1976 Dublin office converted its suite of programs, PFT (Plane Frame and Truss) to run on DEC 10. The first version on DEC 10 was in Basic and later this was replaced by a more efficient Fortran version. These programs became so popular that they were developed further to become what is now known as the FRANCIS system.

One other 9830 was purchased for the Ibadan Office in Nigeria. A version of Superslew, a highway design program, which had previously been mounted on an IBM 370 machine in the university there, was developed.

Much later in 1977 a 9831, similar to, but more powerful than the 9830, was purchased by the Perth Office in Australia. All the programs developed in the UK were sent to this office and required very little adaptation.

The most recent development in Arups has been the introduction of the Hewlett Packard 9845 (see Fig. 6). This has represented a very large step, not only from the vast improvements in the hardware but also in the whole approach to the software, its value, and how it should be marketed. One result has been the formation of a software sales group, Oasys Ltd., to develop and sell programs externally. This group was set up in the London Office in 1978. The rate of development of all aspects of the 9845 has been so rapid that it is inappropriate to do more than outline the most significant points here.

Impressive performance

The two most striking features are the 250×200mm display screen and the vast increase in memory size which can be contained within the standard desk top case. The display screen uses a 560×455 dot matrix and can be used for either graphics or text. This means that interactive graphic systems (e.g. CADRAW) can now be made to work on a desk top machine. It also provides the facility for any results printed on the thermal paper to contain a combination of graphics and text. The size of memory is available in modules from 56 to 449 k bytes (16 bit word). Programs are written in enhanced Basic which is similar enough to Fortran to make translation from one to the other quite practical.

The first 9845 appeared in London on loan in August 1978. In March 1979 a model 'S' (56 k bytes) was purchased followed in June by a model 'T' (187 k bytes). These machines were used primarily to convert the existing 9830 programs to run on the 9845. This achieved the objective to start selling programs as early as possible and in addition anticipated the purchase of further machines for the regional offices.

Further improvements

Eight other model 'T' machines were purchased in 1979 for the offices in Cardiff, Dublin, Edinburgh, Hong Kong, Johannesburg, Manchester, Ibadan and Sydney. Dublin had already converted its 'Frame' suite of analysis programs which had been included in a number of sales. Since the conversion of these and the *CP 110* suite of analysis and design programs many improvements have been made. Other programs are being added which relate to building services, civil engineering and project network analysis.

The configuration for these machines has included the standard features such as two cartridge tape drives and an A4 width thermal printer. In addition an A3 four pen plotter has been supplied and, for the UK machines, a terminal emulator which allows the 9845 to be used as a terminal to other computers. This also allows it to simulate a Tektronix terminal. Other peripheral equipment available includes floppy disk drives, cartridge disk drives, digitizers, and interface units to drive large plotters (on and off line). These have all been included as parts of a package on which to mount CADRAW (two-dimensional interactive drawing production system).

The conversion of CADRAW from DEC 10 to the 9845 is the largest development exercise attempted so far on desk top computers. The work started in November 1979 and is due to be completed in the summer of 1980. The development of desk top computers has now reached a level of sophistication in just over 10 years such that they provide a very attractive alternative for many tasks. The next 10 years of development should be quite exciting for all of us.

The new extension to the Tate Gallery

Architects: Llewelyn-Davies Weeks

Norman Boniface

The Tate Gallery was opened to the public in 1897 and during the 40 years up to 1937 it was extended five times and grew to four times its original size.

Since 1937 no further extensions had been built and the need for more space to display its ever growing collection became critical.

Following a feasibility study in the '60s, approval was given firstly to refurbish and extend facilities within the existing building (Phase I) and then to develop a vacant corner of the site to the rear of the existing building (Phase II). The brief required unobstructed gallery space at the same level as the existing galleries, together with storage facilities in a flood-proof basement for works not on display, plus a five-storey building housing conservation studios and workshops for restoration work.

The structure is generally of reinforced concrete, with the exception of the main gallery roof. This is a steel structure in the form of twin lattice girders of 27m span located at 9m centres, with secondary twin girders spanning onto the main frames forming a total of 21 bays, each 9m square.

Each bay carries a glazed roof light.

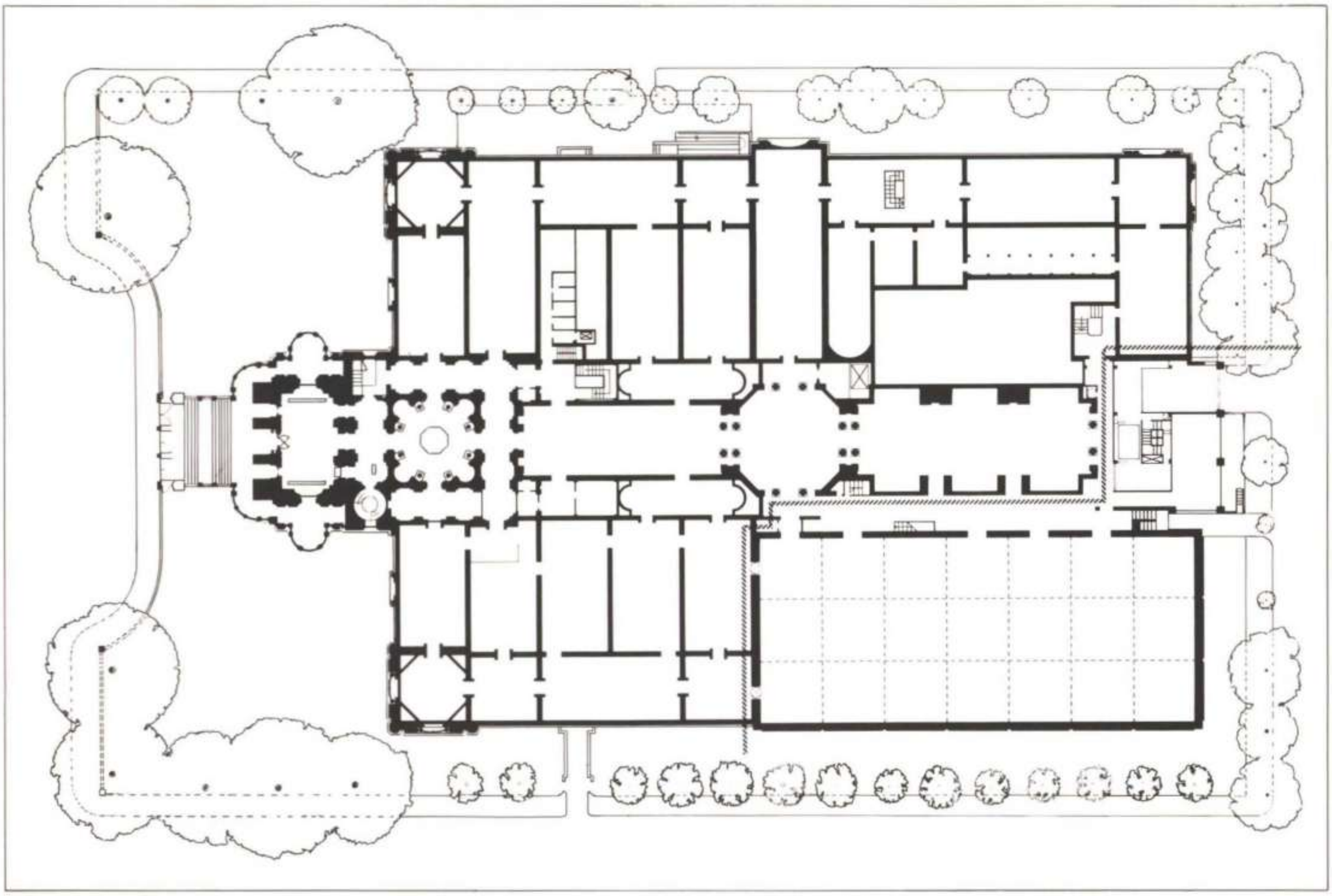

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Fig. 1
Gallery Level plan

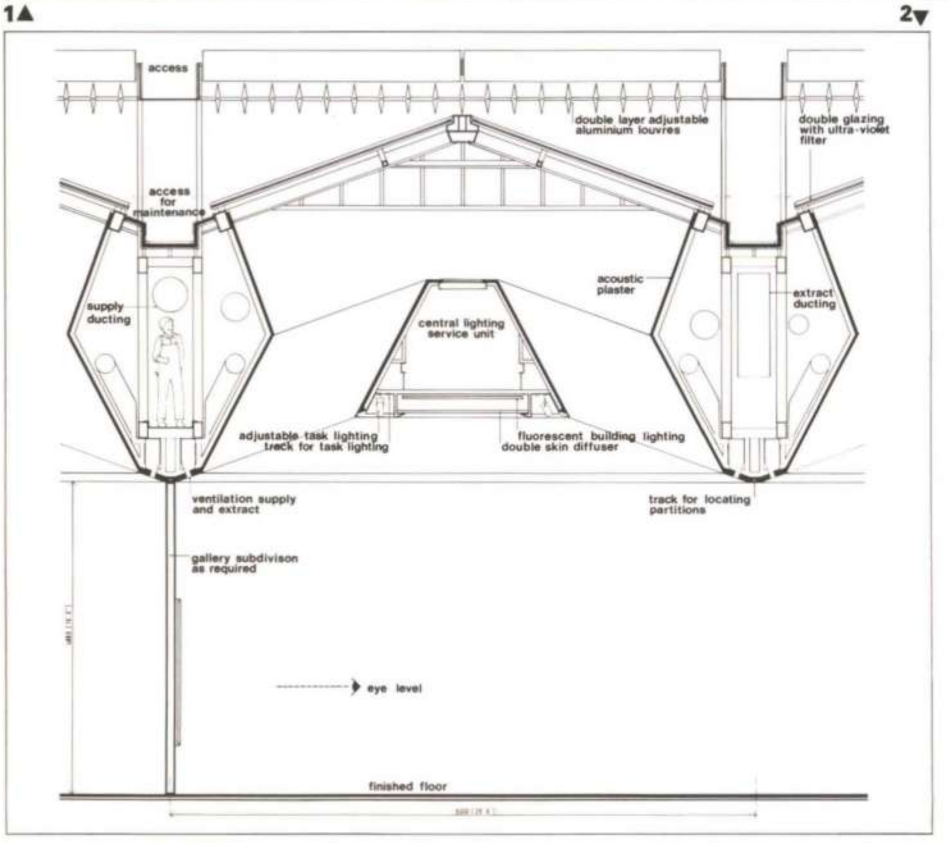


Fig. 2
Typical section through roof

The roof structure carries the air-conditioning equipment so that air can be introduced and extracted from each bay independently, whilst natural lighting levels and amounts of solar heat reaching the gallery are controlled by a louvre system of sun blinds supported on a lightweight steel structure above the roof lights.

A total of 2000m^2 of additional gallery space has been provided together with 900m^2 of studio/workshop space.

The building contract commenced in February 1973 and was completed in November 1976.

Credits

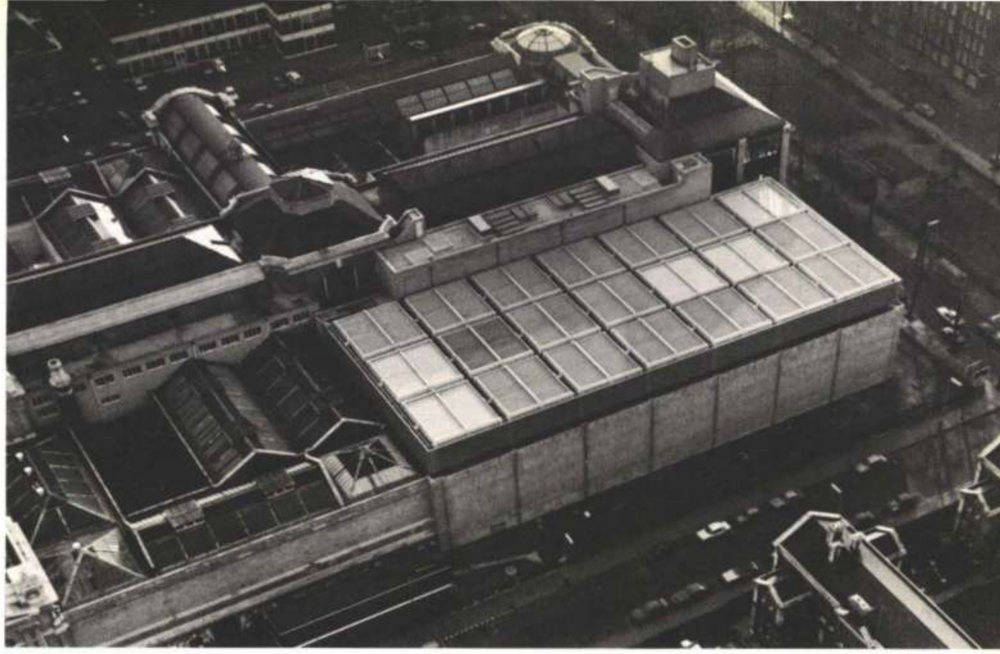
Architects:
Llewelyn-Davies Weeks

Quantity surveyors:
Gardiner & Theobald

Services consultants:
Zisman Bowyer & Partners

Lighting consultants:
Ralph Hopkinson Newton Watson & Partners

3



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5▼

Fig. 3
Interior of main gallery
showing typical 9m square bay
(Photo: Henk Snoek)

Fig. 4
Roof area showing sun blinds
(Photo: Henk Snoek)

Fig. 5
Rear/north elevation
(Photo: Henk Snoek)

Benghazi city roads project

Malcolm Simpson

Benghazi

Benghazi is the capital of Cyrenaica and the second city in Libya. Major commercial and government facilities exist to serve the region. The port, which is currently being extended, is the focus for trade for the east of Libya.

During World War II the city was devastated during occupation by the Italians, British and German forces. Since then it has been reconstructed and, following the revolution which brought Colonel Gaddafi to power in 1969, the reconstruction has been further accelerated. In the past few years there has been a remarkable growth in housing, schools and medical facilities in particular, together with expansion of commercial and industrial areas to support the rapidly increasing population, currently 350,000 and growing at a rate of over 5% per annum. This dramatic growth is inevitably creating great stress in the administrative and commercial systems and is placing large demands on the inadequate infrastructure of the city. Road and transport requirements are reaching a critical stage as car ownership grows very rapidly. In order to find solutions to these problems a series of studies is being carried out including a Regional Master Plan to review the growth strategy for the region, design of water and power supply as well as foul and surface water drainage systems. We are undertaking the review and design of the road and transport systems.

The planning and engineering work for the city is now under the control of the Municipality which is directed by People's Committees. The technical staff are limited in number and the handful of trained and experienced Libyans is supplemented by staff from Egypt, Britain and Eastern Europe. This mixture of nationalities leads to a diversity of design philosophies which makes consistent planning difficult and is further complicated by the demands of local politicians for immediate action. Long-term planning is often sacrificed for the more tangible results produced by immediate, unplanned construction work.

Scope of our contract

In late 1977 we were invited to submit proposals for a traffic study of the city followed by road design and supervision of what we were led to believe amounted to 50 km of urban main roads. Following our submission we were invited to negotiations and were eventually awarded the contract in February 1978. The contract was obtained in the face of strong competition and followed the general pattern of negotiations for such projects where the most critical aspect was our offer of a cheaper service than our competitors. After our contract was agreed, we were asked to design 25 km of urban back streets.

After we had embarked on the contract the length of road steadily increased to over 700 km! Some of this has now been cancelled and our current design target is some 600 km of road of which 440 km have already been designed.

Subject to our successful renegotiation we hope to continue in our role which is effectively acting as the traffic and highway department of the Municipality of Benghazi.

Our fees are based on the number of kilometres designed, together with a man month rate for site supervision staff.

We have also been helping on the supervision of work designed by others which was inadequately designed, specified and supervised. This has led to many complications on adequacy of design standards and responsibility for finished work.

Existing roads and parking

The main road pattern in Benghazi is generally paved and in poor condition due to a complete lack of adequate maintenance. Generally the roads within the developed areas are unpaved, potholed and undrained. They constitute a severe health hazard, lead to dangerous conditions for vehicles and pedestrians and act as a severe deterrent to the proper social, commercial and physical development of the city. A limited number of new main roads has been designed by others but as these have been conceived as isolated routes rather than an integral part of the city fabric they solve one particular problem but will lead to widespread difficulties of access and congestion on the surrounding road network.

Junctions are generally at-grade with some traffic signals but these, together with signs, road markings and lighting, are inadequate and poorly maintained.

Parking conditions in the more densely developed areas of the city are chaotic with parking two, three, or even four abreast. There is very little control of on-street parking and very few off-street car parks.

Public transport is infrequent and usually in poor condition. Shortage of drivers, and again inadequate maintenance, mean that only about half of the buses are in service.

The standard, behaviour and consideration for other users demonstrated by drivers in the city is high for a city unused to a long period of motorization and compares favourably with the situation in Tripoli.

Discipline and behaviour is at present helped by the lack of widespread and prolonged congestion but hindered by the lack of road markings, signs and controls.

Unless these latter factors are substantially improved, driving standards are likely to deteriorate as minor streets are paved and congestion increases.

The worst aspect of driving observed was the lack of discipline at junctions. The most welcome aspect is the care and courtesy shown to pedestrians, particularly children.

Planning context

In 1966, the American planners, Whiting Associates, produced a Master Plan for the development of the city to the year 2000. The Plan defined land uses and a hierarchical road network to cope with the predicted

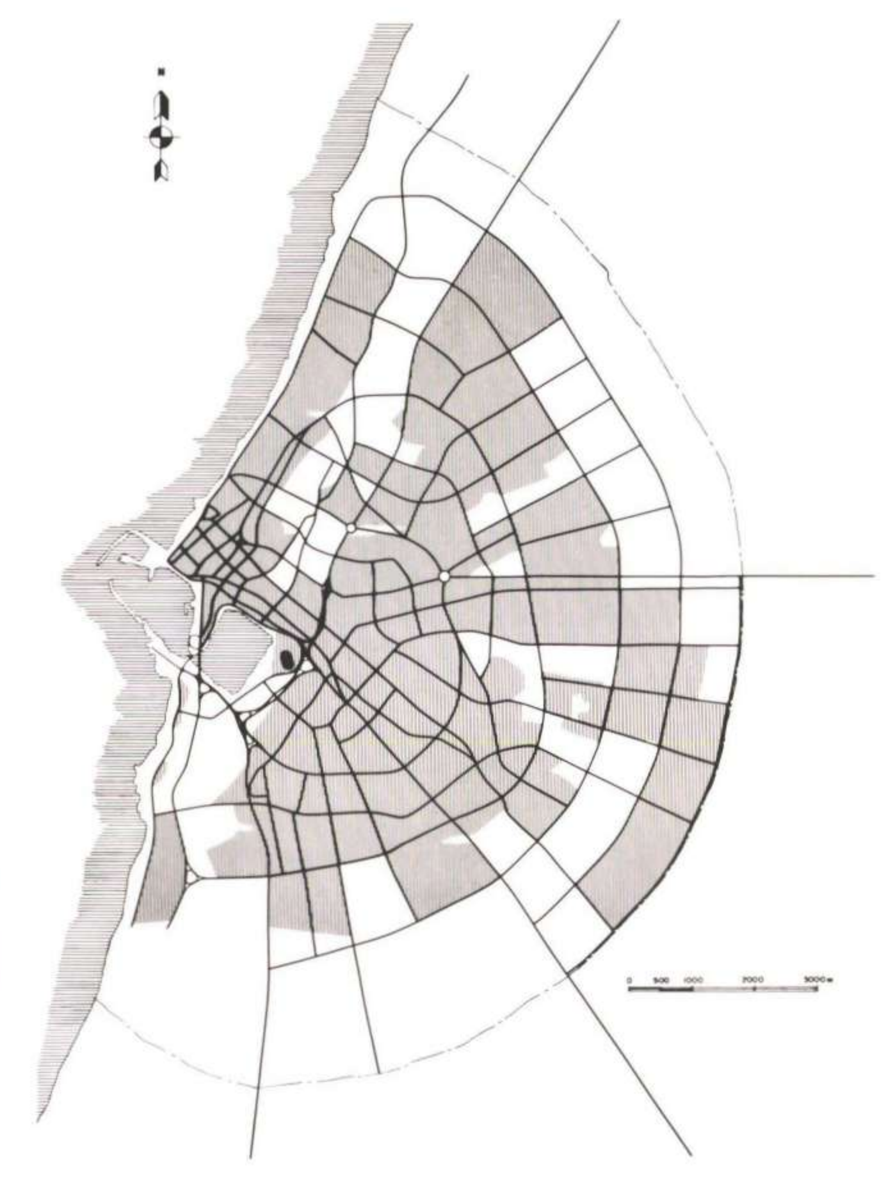


Fig. 1
Benghazi year 2000, from the Whiting Master Plan

Figs. 2 & 3
Lack of traffic and parking controls
(Photos: Malcolm Simpson)

Fig. 4
Side road showing lack of pavement and drainage.
(Photo: Malcolm Simpson)

Fig. 5
Existing main road
(Photo: Malcolm Simpson)

growth in population and economic activity. This growth has been accelerated by the increase in oil prices but generally the planning of the city has followed the concepts of the Master Plan.

The city has grown around the centre piece of the harbour but its development has been greatly influenced by the salt marshes which have forced development to go in two directions. Outside the central area of high density residential, shop and office uses, the land is more exclusively used for residential areas of different densities. Further out, light industry and warehousing are interspersed with residential uses but there are plans to concentrate all industry into a single new industrial estate. Throughout the city many schools, recreational and medical facilities have been constructed to serve the local population and in particular the high proportion of children. The growth in economic activity has allowed employment to keep pace with the expansion in population. However, the pattern of employment has changed with swings to large-scale construction industries and a high proportion of people employed in general public services.

The most critical change in the Whiting Plan has been the concentration of employment in the City Centre as opposed to the more diverse employment pattern proposed in the Master Plan.

Random changes in land use policy are imposed from Governmental level, a prime example being the industrial estate mentioned above. The planned area is some 1500 ha and we are now working on the third possible location for this area.

Travel demand

The road pattern of Benghazi is based on the spider's web, ring and radial pattern. This leads to a high concentration of traffic at the centre of the City which is least able to accommodate the demand because of high density development and high parking demand.

10 years ago the size of the city allowed most trips to be undertaken comfortably on foot. At the city's present size a high proportion of journeys are of a length to make motorized transport highly desirable. The increase in access to private transport has provided greater opportunities for inhabitants to make these longer trips, thus increasing traffic flows.

In the older established areas of the city residential and employment generating land uses exist side by side. In particular these areas have a large number of shops and many small craft, manufacturing and service workshops. This mixture allows residents to satisfy locally their social needs and provides a high proportion of employment near their homes. Many trips are therefore over short distances which do not involve the use of motorized transport.

The most worrying aspect of current planning policies is the lack of employment opportunities in the new residential areas. This concept is alien to the traditional Arab cities and has caused considerable difficulties in other countries with highly developed transport systems. Inhabitants of the new residential areas away from the city centre are therefore obliged to travel long distances to work, for shopping and other personal business trips.

Traffic study objectives

As in any other large city, transportation planning in Benghazi is subject to a large number of potentially conflicting pressures such as vehicular access and circulation, pedestrian safety, ease of parking, public transport provision and economic and financial constraints. In order to help decide the optimum level for these factors, the objectives of the traffic study were:

(1) To provide an efficient private and public transport network for all users.

(2) To provide a transport infrastructure which is sufficiently flexible to allow for alterations in the City Plan and will accommodate further expansion.

(3) To provide realistic and practical solutions allowing for local social views, technical skills available and financial resources.

(4) To enhance the safety of movements, especially of pedestrians.

(5) To retain and improve the interesting facets of the existing urban townscape and seek improvements in environmental conditions.

Data collection

The rapid physical and social changes that are under way in the city will have a profound effect upon the pattern of future traffic movements. Under these circumstances a simple extrapolation of existing movements is not a valid method of predicting long-term traffic patterns. It is necessary to take into account the changes in land use, population and social habits. In addition, the effects of policies adopted by the Municipality must be evaluated to assess their effect on the future transport situation.

In order to produce an acceptable model, simple volumetric traffic surveys are insufficient. In addition to extensive consultations with all relevant local bodies including the police, public transport, docks and airport authorities, the following surveys were undertaken.

(1) Road inventory – to establish details of existing road geometry and conditions.

(2) Classified counts – to investigate volumes of traffic for calibration of the model and to assess road and junction capacities.

(3) Journey speeds – to assess the degree of congestion on main routes and to establish speed/volume parameters for the modelling process.

(4) Roadside interviews – over 15,000 interviews were carried out at police manned control points in order to determine spatial distribution of trips, journey purposes and vehicle type and occupancy.

(5) Parking study – to identify areas where parking demand exists and its effect on the road network.

In addition, desk studies were carried out on population, land use and economic data for the city.

Summaries of some of the survey data revealed the following information.

Modal split	%
Bus, coach, cycle	2
Heavy commercial	3
Light commercial	14
Taxi	9
Car	72
	100

Journey Purpose

% of all trips	To work	From work	Business	Shopping	Education	Social	Other
a.m. peak:	50	5	13	4	11	3	14
p.m. peak:	15	25	12	10	3	18	17

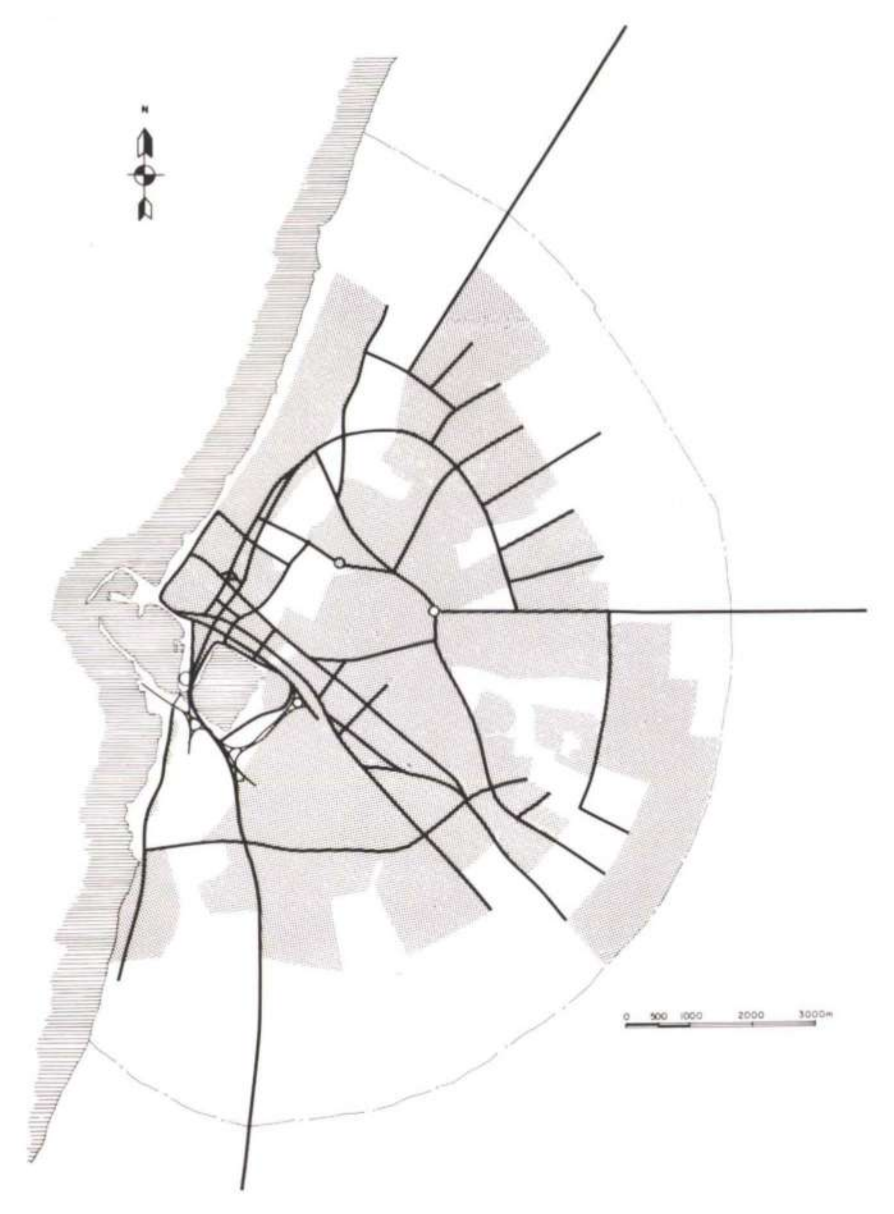


Fig. 6
Benghazi 1978

One noticeable feature of the trip distribution is that journeys with no origin or destination in the city amounted to no more than 1% of light vehicle trips and 4% of heavy vehicle trips. These figures immediately disproved the theory held by some local planners that a by-pass would solve the traffic problem in the centre of the city.

Data analysis

Current statistics show that the population is growing faster than the Master Plan predictions. It was therefore necessary for estimates to be made of the unrestrained growth assuming that current attitudes to natural population increase and immigration to the city remain unchanged. Any policy changes would take time to show significant effects and the short-term forecasts are thought to be valid even if long-term projections may well change.

Year	Natural increase	Total including immigration
1964	—	137,000
1977	311,000	311,000
1980	363,000	385,000
1990	601,000	723,000
2000	977,000	1,262,000

The rapidly increasing affluence of the people, together with the high growth in population, lead to the following dramatic increase in the unrestrained demand for vehicles.

Year	Cars per 1000 population	Total number of vehicles
1978	21.9	108,000
1980	25.4	138,000
1990	36.7	346,000
2000	39.6	646,000

These long-term figures are not used as a design target but as a basis for establishing a transport policy and any restraint measures necessary. The demand shown above could not possibly be accommodated within the current context of the city plans and policies.

The modified Whiting Plan was used as the basis for land use input to the traffic model which is summarized below:

(1) The city was divided into homogeneous zones.

(2) The information collected in the roadside survey was coded, punched on cards, and edit checks were carried out.

(3) The data was then rearranged into origin/destination matrices for different vehicle types, time periods and trip purposes to represent all movements in the city.

(4) The existing road network was modelled using speed/flow data from the surveys to represent the 'resistance' of each link.

(5) The origin and destination matrices were assigned to the road network using an incremental loading procedure in order to model the effects of traffic volumes and congestion on each link.

(6) The results of modelling the existing trips and network were calibrated by reference to the volumetric counts, and the parameters were adjusted until satisfactory correlation was achieved.

(7) Different combinations of land use and road network parameters were tested by scaling up the trip matrices using population, employment and car ownership data and by revising the modelled road network. These tests were carried out for different time periods and different design years.

Land use/transport options

As the demand for travel rises it becomes increasingly difficult to satisfy this demand. The use of a car gives accessibility to shops, offices and businesses but can be its own enemy when there are so many cars that parking is difficult and congestion makes movement slow and unpleasant. Public transport will always be needed for people who cannot afford a car or who do not have one available and the increasing population will mean that public transport demand will increase. General traffic congestion will make public transport slow and unreliable even if the problems of staffing and maintenance are solved.

In order to improve road safety, road building must include signs, marking, lighting and pedestrian facilities.

In the longer term, congestion, difficulty of access and an unpleasant environment created by unrestrained car use have an effect on the distribution of housing and employment and can stifle the growth of commerce and industry.

Solutions to these interrelated problems can be sought in several fields. New road construction, better control, greater provision and use of public transport, design and installation of pedestrian facilities and off-street parking provision will all help the safety and efficiency of movement. A balance must be struck between the different solutions to the various problems.

The three fundamental possibilities for improvement lies in more roads, better public transport and optimum land use allocations.

The first two will remain important because the central area and sub-centres will retain their importance and radial traffic movements will increase. However, in Benghazi, these two solutions alone are not likely to resolve the situation and some amendment to the planned land use pattern is required.

The development of industry outside the town would be useful in dispersing employment, but, as industry accounts for less than 10% of employment in Benghazi, a new industrial area cannot be expected to produce spectacular results.

In order to test different emphases in policy, four options were modelled:

(A) Unrestrained car use, centralized employment.

(B) Unrestrained car use, decentralized employment.

(C) Car use restraint, centralized employment.

(D) Car use restraint, decentralized employment.

In addition, various modifications to the road network were tested in order to improve its efficiency. The policy and network options were then tested and evaluated against the stated objectives. The evaluation could only be partially quantitative as no research has been carried out on valuation of people's time, effects of noise, pollution and accidents. A full cost benefit analysis could not be used without this background research.

Analysis of the traffic flows for these strategies showed that both A and B would lead to severe congestion in and near the centre. Option C, although reducing congestion, would require the construction of a large number of car parks in the centre and would not be conducive to the creation of an efficient and economic transport system. Option D would further reduce traffic flows in the centre and would utilize the high capacity ring roads to a greater extent. It would also achieve a better balance of public transport movements and require less parking provision in the city centre. It was therefore recommended that a strategy of dispersed employment, together with restraint of car use in the central area and the provision of a strong public transport system on radial routes, be adopted.

The detailed analysis of the preferred option led to the formulation of a staged road network to overcome the immediate problems and to allow for long-term future construction. As the latter is dependent on many unknowns, the road network recommendations have been planned to cater for the maximum degree of flexibility in the choice of land use employment and transport options.

Our proposals were accepted by the client and led to the design programme for roads on a logical basis which had not existed before, all roads being constructed as matters of local expediency.

Road design

The most important aspect of the road planning was to identify the function of each road in order to establish suitable design parameters for cross-section, design speed, junction spacing, parking control, frontage access and pavement design. The roads were categorized as shown in the table below.

At present there is a skeleton of Category I and II roads and a well developed but poorly constructed system of Category IV roads. There are however very few Category III roads except in the new areas towards the periphery of the city. This dearth of an intermediate system has serious consequences on the efficient functioning of the Category I and II roads due to a multitude of local roads joining the main roads which cause severe congestion.

Category	Function	Frontage and access conditions
I	To carry main traffic flows and serve as the primary road network	No frontage No access
II	Distribution of traffic to City neighbourhoods	No frontage No access except very major land uses
III	Distribution of traffic within neighbourhoods	Limited frontage Access to major land uses
IV	Distribution of traffic to individual properties	Frontage Access to frontage properties

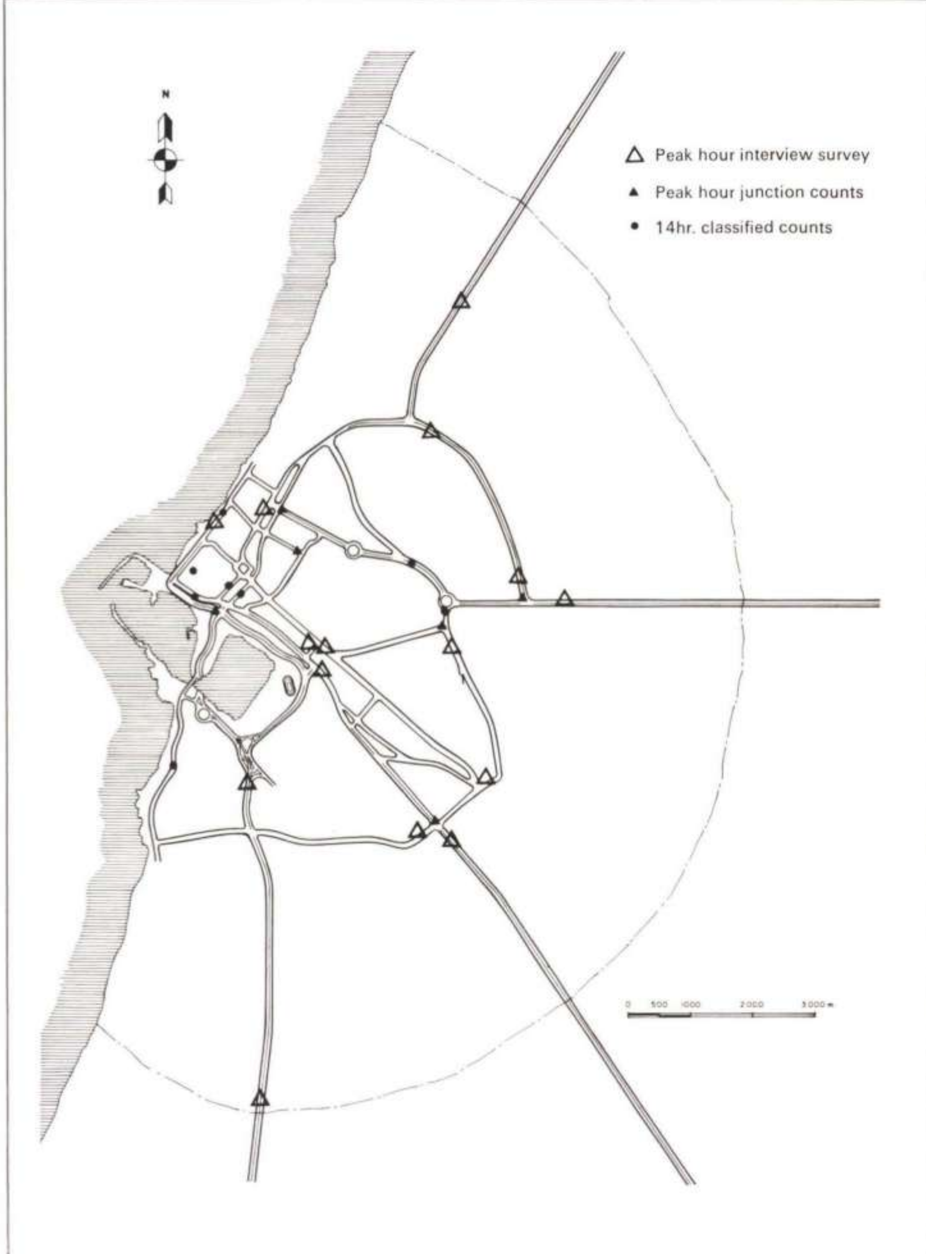


Fig. 7
Traffic survey stations

The majority of roads in the design programme are Category III and IV and the construction sequence is based on the provision of water, power and drainage systems. The programme for the higher category roads is generally based on the traffic flow requirements.

Design of roads has generally followed the Master Plan corridor and demolition kept to a minimum, as the demand for housing exceeds supply and the obligation to provide alternative accommodation for displaced uses makes acquisition of property a very lengthy process.

Design standards

As the client had no recognized standards we have had to rationalize road details, junction spacing and designs, specifications, standard bills of quantities and construction details appropriate to local conditions.

Category III and IV roads

The design of local road networks follows planned corridors but provides for improved environmental conditions by means of traffic management measures such as one-way streets, selective road closures and limitation of the number of junctions. These measures are designed to keep through traffic out of residential areas, provide parking for local shops and community facilities away from main roads, and improve the flow and safety of traffic in the area.

Category I and II roads

The main roads provide for appropriate traffic capacities derived from the traffic report within the land and environmental constraints existing, Where possible, service roads are provided near areas of high car activity such as major shopping centres and hospitals. The aim of the design has been to impose a self-enforcing control of parking and circulation by means of suitable layouts rather than relying on manned enforcement of regulations.

Contract documents

We have produced locally applicable specifications for roads, road furniture, signs, lighting and landscaping.

Bills of quantities are now produced in a more comprehensive and logical format than the original project we took over, in which 25 km of roads had been covered in a bill of quantities covering one A4 sheet.

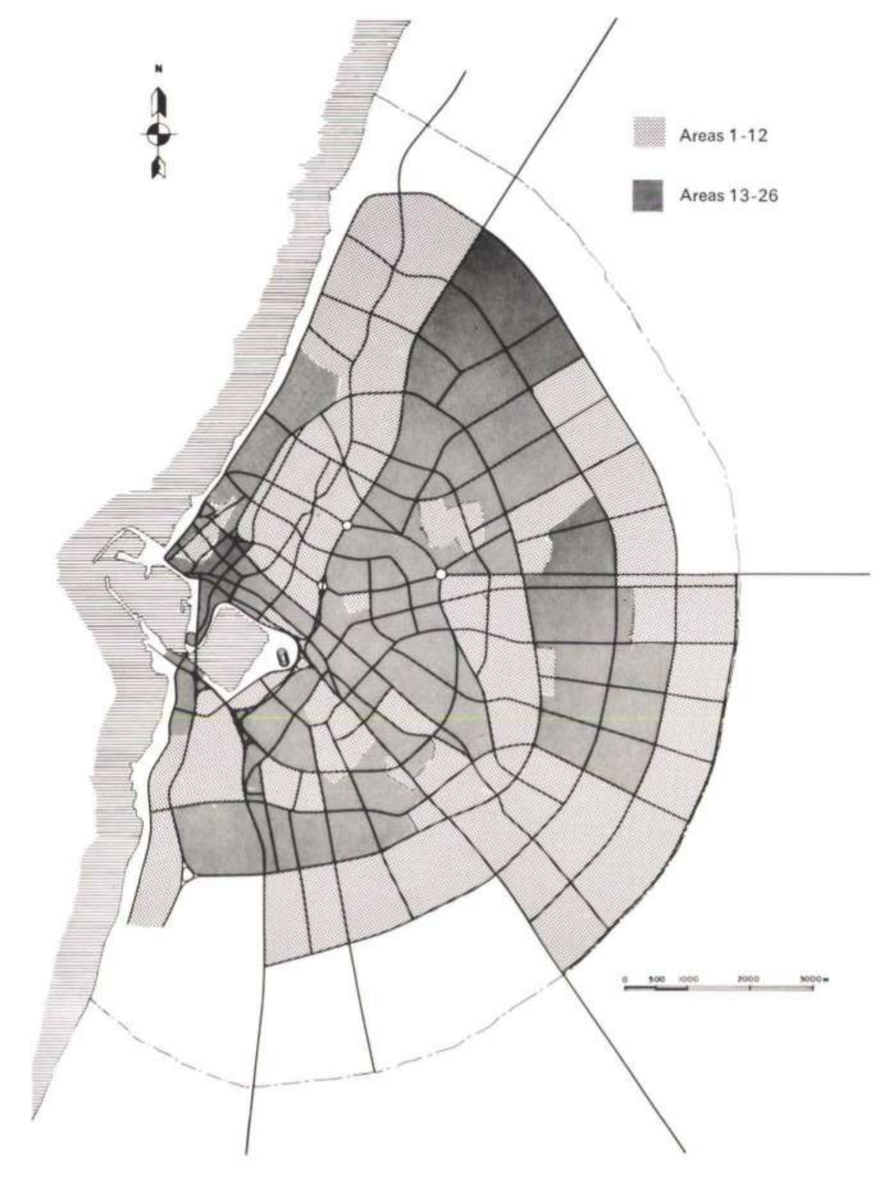


Fig. 9
Contract areas

Figs. 8 & 10
New roads under construction
(Photos: Malcolm Simpson)

Contracts

All contracts are lump sum contracts based on agreed rates. No extras are claimable under Libyan law, which has caused considerable consternation to our contractors. Examples have included the case where local quarries were closed for environmental reasons and the material had to be hauled an extra 50 km with no additional payment. Import of certain vital materials can also be prevented by refusals of import licences. Contracts are generally awarded to nationalized Libyan contractors who have no significant plant or labour resources and who subcontract to other firms. We currently have Italian, Greek and Yugoslav contractors but they find conditions very difficult due to slow payment, changes in regulations and supply of materials. Another example of the difficulties they face was the instance where numerous labourers had appeared and told the contractor they were working for him. He did not want additional labour but could not legally refuse the local 'job centres' instruction to employ these labourers.

Despite all of these frustrations our site staff are working under unknown conditions with new documents and unknown contractors and it is to their credit that some contracts are progressing and enabling us to see the first fruits of our labours.

The future

By the time this article is published we should know whether we have a further two years to run. We are looking forward to continuing our work despite the frustrations and financial problems and we believe that our client and the people of Benghazi are beginning to see the benefits of our efforts.

We can only achieve a small portion of what we would wish to do but at least we are bringing some logic and order into a situation which was uncontrolled and would have deteriorated rapidly in the near future if no action had been taken.

1▲

2▲

Concrete Society Awards 1980

Winner: Civil Engineering

Figs. 1-3 Byker Viaduct,
Tyne & Wear Metro (Job No. 4914)
Designed by Ove Arup & Partners,
Civil Engineering
Consulting architect: Renton Howard
Wood Levin Partnership
(Photos: Ove Arup & Partners)

Commendation: Building

Fig. 4 Carlsberg Brewery,
Northampton (Job No. 3772, etc.)
Architect: Knud Munk
Prime agents: Ove Arup & Partners
(Photo: Colin Westwood)

Commendation: Building

Fig. 5 Harriston Village,
near Aspatria, Cumbria (Job No. 4569)
Architect: Napper, Errington,
Collerton & Associates
Structural engineers: Ove Arup & Partners
(Photo: Philip Sayer;
copyright *Architects' Journal*)

Special Mention: Building

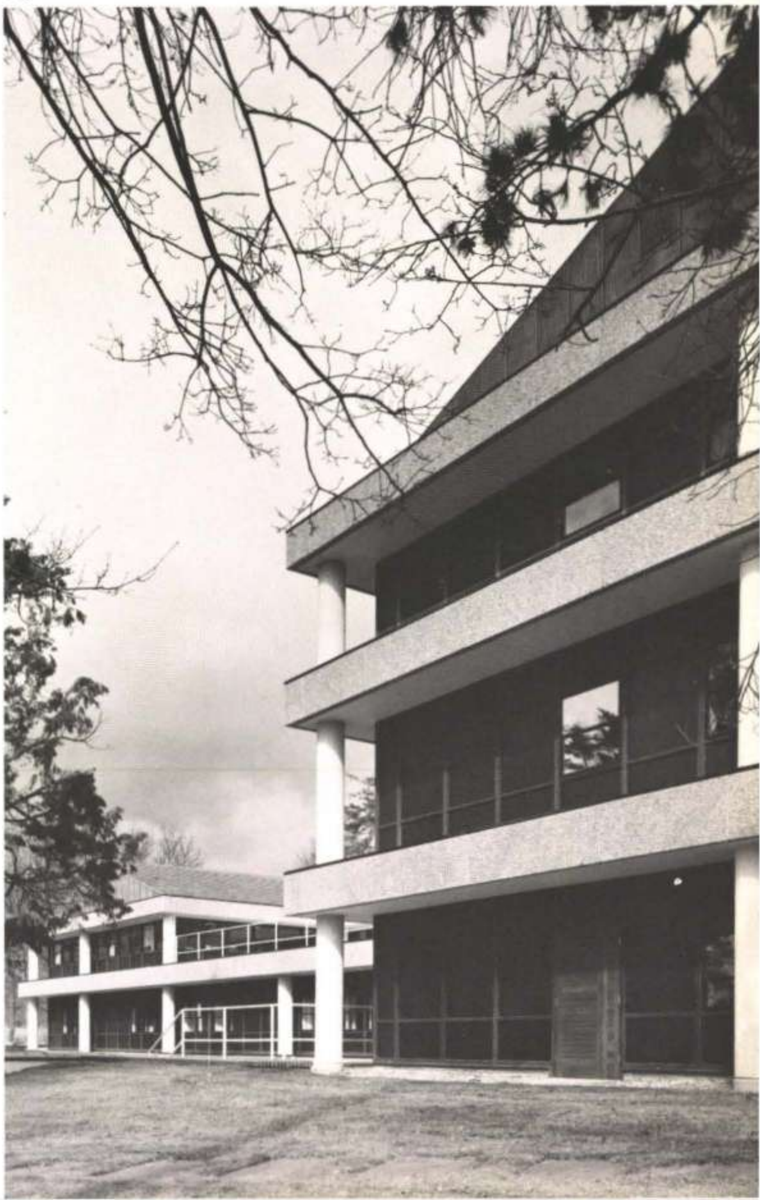
Fig. 6 Winslade Manor, Clyst St. Mary,
Exeter, Devon. Offices (Job No. 5968)
Architect: Powell & Moya
Structural engineers: Ove Arup & Partners
(Photo: Henk Snoek)

3▼

4 ▲

5 ▼

6 ▼



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