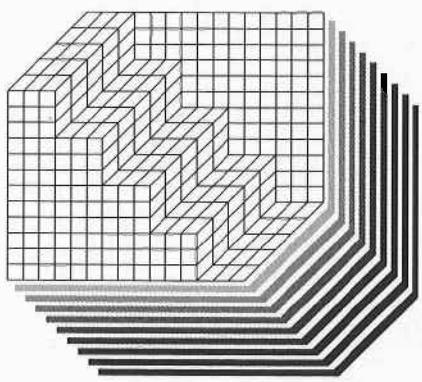
Patterns 11



Patterns 11

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A Journey in Saudi Arabia

My experience of working in Saudi Arabia spans almost 30 years. It started in the 1960's when I was an executive partner of structures 3 at Ove Arup and Partners, and has continued to be a happy, fruitful experience to this day.

I went to a Quaker school in York called Bootham and when in the early 1960s the name appeared on the job list in Ove Arup and Partners, I asked if I could be the engineer for it. The architect was Trevor Dannatt and a fellow engineer, John Martin, not only looked after Trevor's work but actually had 'digs' in his house. John is a generous man, he let me do it, and a very close friendship between Trevor and myself developed. So when in 1966 the government of Saudi Arabia held a UIA limited competition for a conference centre and government guest house, and Trevor was asked to enter, I went along as the engineer, doing the work at weekends.

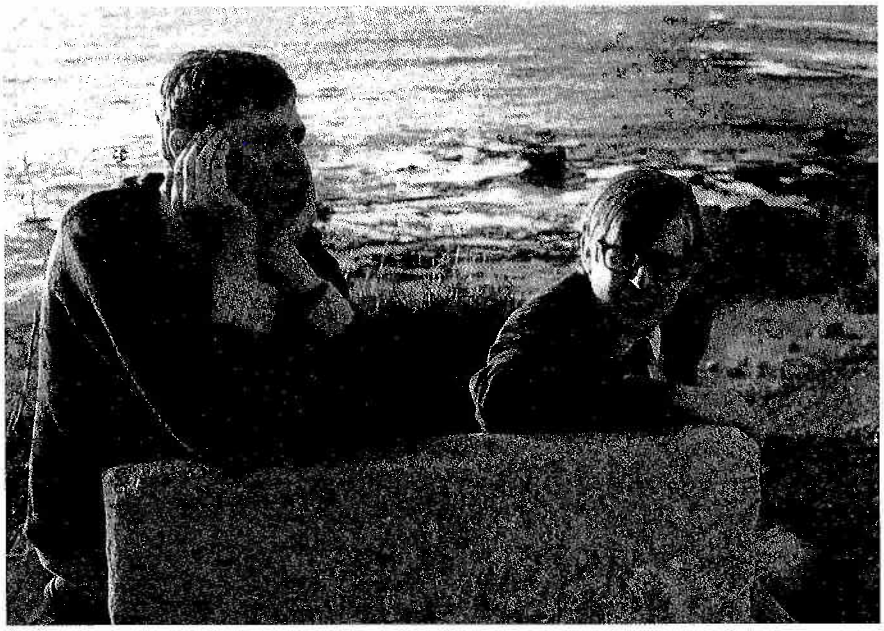


Fig 1.1 Trevor Dannatt and Ted Happold, Lebanon, 1967

It was not a country Trevor or I knew much about - in fact very few people knew much about it at that time. Land of Abraham and Mohamed, and once the centre of an empire that stretched from Spain to India, it was, by the beginning of this century, broken up into a whole series of tribal areas. Riyadh was a small town held by another family, the Rashid, while the Saud family, the traditional rulers, were in exile in Kuwait. In January 1902, Abdul Aziz, the eldest son of the Saud family, led a raiding party of 40 men to try to recapture the town. With six of his men he climbed over the mud brick walls of Riyadh, opened the gates to the rest of his followers and hid for the night. Next morning they attacked the Rashid governor as he came out of the fort with his bodyguard and, though heavily outnumbered, won a short fierce battle to regain the town. In the years that followed Abdul Aziz consolidated most of Saudi Arabia. A deeply religious man, he founded religious cooperative farming communities in order to reduce the tribal divisions and to provide a readily available army. In 1913 he drove the Turks from the Eastern Province; in 1925 he drove the Hashemites out of the Hejaz.

In 1938 the Standard Oil Company struck oil near Dhahran but the King was slow to let westerners freely into the country. He died in 1953 and was succeeded by his son, Saud, a profligate man who was deposed in 1964 in favour of his brother Faisal. Under Faisal's rule the country started to be opened more to the west, though tourism is even now not encouraged. It was King Faisal's liberal policy that led to the conference centre competition. An attempt had been made to hold an international medical conference in Riyadh and the facilities had been totally inadequate. The King decided that increased world participation meant a need for conference facilities. He would link that need with setting a higher standard of building. The United Nations planning advisor was Dr Oman Azzam, a well related Egyptian architect, and the Saudi government got him to ask the Union Internationale des Architectes to organise a competition and they appointed Theo Crosby as the technical advisor.

The competition defined a site in Riyadh but the King in fact had decided to build three: one in the east in Dhahran, one in the south in Jeddah, and one in the centre in Riyadh. Riyadh would go to the winner, the second would get Dhahran and the third prize winner would get Jeddah - together with the town planning! We tried to lobby to come third! Our entry went off and we half forgot about it until a cable arrived, rather to Trevor Dannatt's horror, asking us to build the Riyadh one. It turned out that we were going to come third, and then the judges asked the King to visit the exhibition. He walked in the room, looked at the models - ours was particularly stunning - put his hand on ours and said he would have three of them. The judges spent the rest of the day trying to change the King's mind!! A final compromise was that we would do Riyadh and one other would be built in Mecca, designed by Rolf Gutbrod and Frei Otto.

On New Year's Day 1967 Trevor Dannatt and I went out, via Beirut, and started agreeing a contract; hard work with only our pens, no typewriter, it literally having to be handwritten and with no means of telephoning or even writing home. We were there three weeks, and in the middle of it, Rolf Gutbrod arrived with two of his staff, Hermann Kies and Hermann Kendel, and they were only too happy to find us working. Obviously many of the problems of the two

Fig 1.2 Rolf Gutbrod and representatives of the Ministry of Finance, Riyadh 1967

Fig 1.3 Rolf Gutbrod, Herman Kendel and Ted Happold, with representatives of the Ministry of Finance, Riyadh 1967

projects were the same and when Rolf Gutbrod and Frei Otto asked if I would also be their engineer, it was agreed. This really formed two very closely knit design teams.

The two projects together were very big. Fortunately Ian Liddell wanted a change from Holst and rejoined Ove Arup & Partners to be in charge of Riyadh whilst Ting Au ran Mecca, though Peter Rice came back from Australia via the USA to work on the roofs. Both designs are unusual; Mecca so much so that it subsequently won an Aga Khan award as the most technically innovative building for a decade in the Islamic world. Apart from the standard of design though, the interesting aspect was the relationship with the clients, for whom it was an entirely different scale of project (it was pretty big for us too!) and one which represented an influential start to Saudi Arabia's modern era of construction.
In Saudi Arabia at that time, an architect alone being appointed and negotiating his own contract meant normally that only an outline engineering design would be brought

Fig 1.4 Souq, Riyadh, 1966

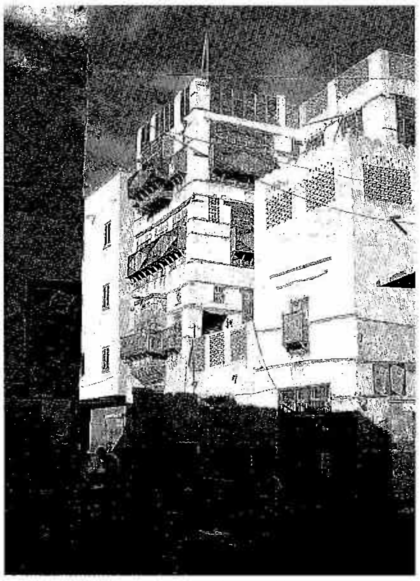


Fig 1.5 City Centre, Jeddah 1966

Fig 1.6 Hotel and Conference Centre, Mecca

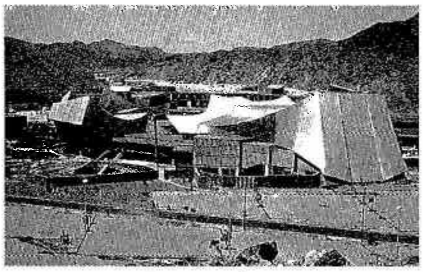


Fig 1.7 Auditorium and Seminar Rooms, Hotel and Conference Centre, Mecca

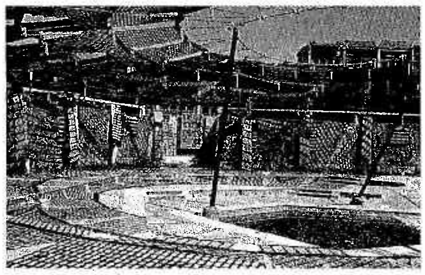


Fig 1.8 Shade Structures, Hotel and Conference Centre, Mecca

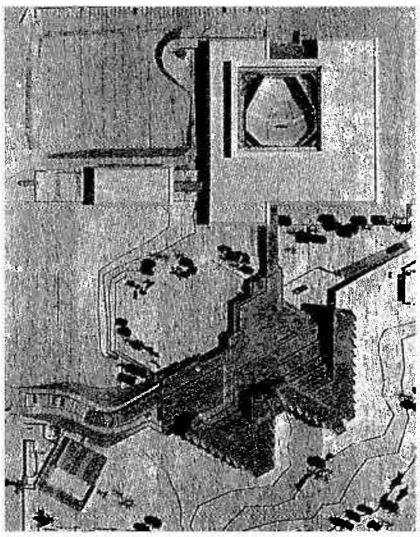


Fig 1.9 Hotel and Conference Centre, Riyadh, model

by the architect and no detailed design and no supervision responsibility was accepted. As we were architect/engineer 'partnerships' we had genuinely tried to include every service we thought the client needed in the belief that we were not only building architecture but also setting wholly new standards for the country. Not only was all detailing carried out before construction, but contractors and subcontractors were interviewed in depth before being allowed to tender and we had very skilled and experienced site supervision crews.

Like all projects there were problems. Civil engineering projects were at that time often of such a scale that there was international competition, but this was not yet true in building. So, as there were not yet any significant national building firms in Arabia we had a duty to try to bring in the best in the world to carry out the construction. Suddenly we were operating in an international scene, comparing contractors and specialist subcontractors worldwide. Both projects went out to tender in 1968 and COGECO, an Italian firm headed by Otto Vannucci, whom I had met when studying the Italian building industry for the DOE when working on the British Embassy Rome, won the Riyadh project. Together with the architects we had the responsibility of supervising the work on site. Only Muslim engineers were allowed into Mecca and there were not so many available at that time. There had been talk of supervising by television but common sense prevailed and a site office for both the contractor and ourselves was set up at Hadda, on the border of Mecca. A partnership had been formed of a Lebanese firm of contractors, Joseph Khoury, and the French firm of Thinet, but the latter had to take over most of the work and employed some very competent French Muslim workers. For the supervision both the architects and engineers also employed muslims but working in Mecca had such a strong influence on several of the German architects that they converted to Islam and are practising muslims.

The projects had been envisaged as conference centres with government guest houses attached. However, as public access to the hotels was open and they were practically the first major ones available, they were immediately enlarged. The hotels became very successful and the conference centres became a lesser adjunct, and the main reason for this success was that they were designed and built to such a high quality. Riyadh is now known as the Intercontinental and is famous. Mecca has less international prominence because of its location but won the Aga Khan Award and

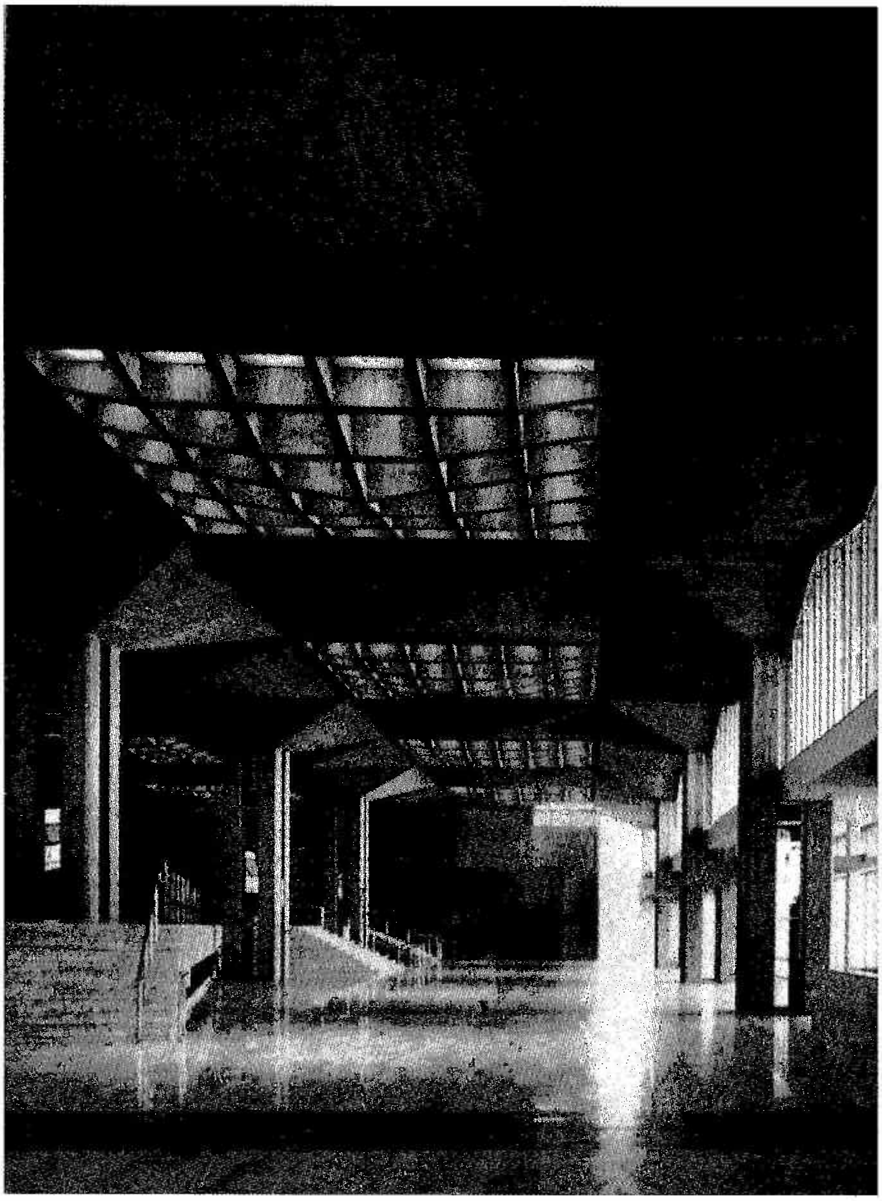


Fig 1.10 Main Foyer, Hotel and Conference Centre, Riyadh

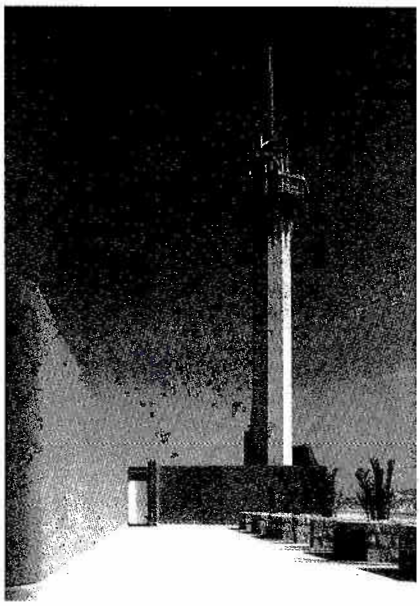


Fig 1.11 Minaret, Hotel and Conference Centre, Riyadh

was a major force in Rolf Gutbrod and Frei Otto winning the Perret Award of the UIA.

The Saudis are very conscious of living in a harsh desert environment and this is an important influence on relationships between people. When they liked you they wanted to discuss things with you all the time. As the government advisors and officials started to understand what we could achieve, they wanted introductions to other western architects. Trevor Dannatt introduced Sir Leslie Martin, who designed a major government centre for the mountain town of Taif for use in the summer, and Sir Leslie used our ideas for massive 'mushroom' shade structures where the services ran within the columns and the soffits reflected thermal movement. Sir Leslie in turn introduced Franco Albini, an Italian architect, who designed the municipal offices in Riyadh.

Continuing to work there was, oddly enough, not quite so easy. Although potential clients wanted the quality we had achieved and so exactly the same service, they seemed persuaded again into giving architect-only contracts with the engineering left to the contractor. We carried out a whole range of interesting small projects on time basis though, including redesigning the entrance to the Zamzam water spring in Mecca, and an appraisal of the government hospitality palace in Jeddah.

It was a wonderful time enhanced further when Professor Karl Schwanzer, an Austrian architect and planner, asked if we would be interested in being considered, against competition, for all the engineering, costing and programming aspects of the masterplan for the University of Riyadh, which had been given a two mile by one mile site on the edge of the city. We did the management and civil and structural work, and subconsulted the building services and surveying. Developing an architectural, functional and economic logic to the plan was fascinating, taking into account the climate, flood prevention, the geology and costs of earth moving, traffic movement, buses and parking, building maintenance and so on. The University had the presentation of all the work spread out over a week, and every aspect of the design was examined and discussed. Not only were the technical staff of the University there, but two planning experts, Horst Linde, former state architect of Baden Wurtenburg and Professor of Design at Stuttgart University, and Francois Vigier, Professor of Urban Planning at Harvard University, were brought in to lead the discussion. Rod Macdonald

Fig 1.12 Hadj walkway shading study

was the project leader and joins me in remembering with pleasure the rigour and good sense in the final formulation and acceptance of the plan.

We did not continue with the work, and Karl Schwanzer unfortunately died. But we had met a whole generation of gifted and well educated young Saudi engineers when they cross examined us and discussed the work with us. Some of them have worked with us, and some we have met later as our clients. The knowledge and experience was building up and there is no doubt that the very broad basis of consultation often achieved a very high standard of work. One can very easily question now whether public authority and private decision making are as efficient elsewhere.

One of the more interesting projects just after this was a limited competition for the replanning of the area around Mona for the Hadj, the annual pilgrimage. Oddly enough Rolf Gutbrod and Frei Otto had been asked separately but there was great integration between the two. Here we met for the first time a young Saudi Arabian architect, Sami Angawi, who came with Bodo Rasch from the University of Austin in Texas to work on the entries. Sami comes from one of the families who hire tents for the Hadj, and his experience of the process of the pilgrimage, for most of the way a crowded walk in hot sun, with stops for stoning the devil, for sacrifice, sleeping accommodation and the like, did lead to a fascinating solution. Alas, as the competition was going on another Ministry was carrying out major changes, and our efforts were abortive. But Sami, helped by Bodo, started the Hadj Research Centre at the University of Jeddah and Buro Happold, just established, got appointed with Arups as engineers for the King Abdul Aziz University sports hall, which Eddie Pugh wrote about in Patterns 5. Arups did the ground works and we did the superstructure and the cable net solution was then the largest fully enclosed structure of its kind and remains to this day one of the most elegant cable net structures ever achieved. Frei Otto and Rolf Gutbrod were the architects,

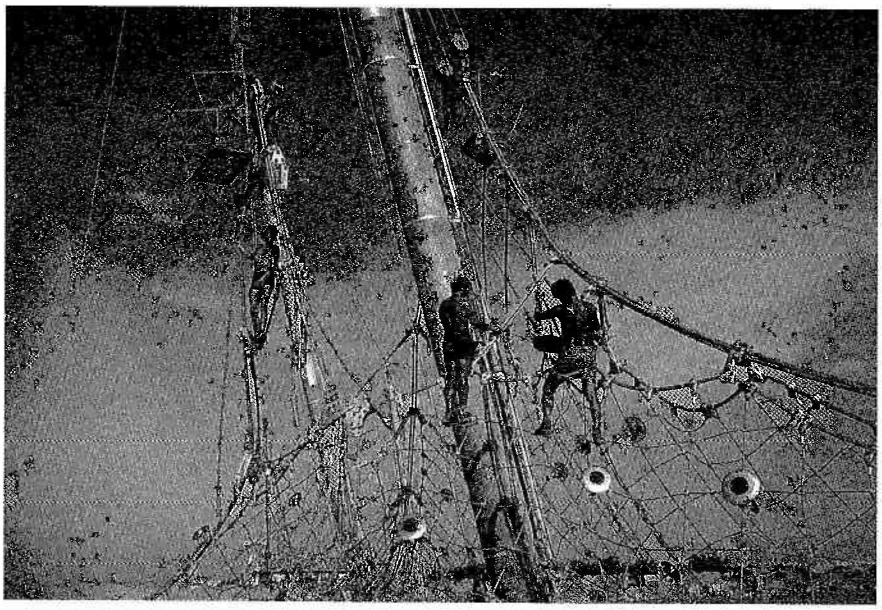


Fig 1.13 Cable net erection - Jeddah 1979

continuing their partnership established in Saudi Arabia for the Mecca Hotel and Conference Centre.

At about the same time, Rolf Gutbrod was in discussion with the Ministry of Finance for King Faisal's plan for a government complex which would house the King's office, Council of Ministers and Majlis Al Shura (consultative council - in essence a parliament). I went with him to finalise the design contract, and as Buro Happold was just then being established, we all agreed that the design work would be carried out jointly by Rolf Gutbrod, Ove Arup and Buro Happold, with a number of other international consultants acting as sub-consultants. We referred to the project as 'Kocommas'. This was a bold project, with translucent marble facades and exciting hexagonal grid funicular lattice shell roof structures which we helped Frei Otto to develop. The design was completed, but impetus for the project waned after the assassination of King Faisal, and though a substantial initial site works contract was completed, the project was eventually shelved.

At the time that the Kocommas initial works contract was on site, Trevor Dannatt was appointed by the British government for the design of the British Embassy in Riyadh, and we were appointed as engineers. The Embassy is located in the Diplomatic Quarter of Riyadh, and we had also entered a competition for the Diplomatic Club, together with Frei Otto and the San Francisco firm of architects, Sprankle Lynd and Sprague. We won the competition, but failed to finalise a contract just as British television screened the controversial 'Death of a Princess'. We thought that was the end of our chances of being awarded the project, but the client, the Bureau for the Diplomatic Quarter, waited a year, till relations between Saudi Arabia and Britain returned to normal, and they again invited us to discuss a contract with them, but now with Omrania as architectural partners rather than Sprankle Lynd and Sprague. Dale Sprankle very graciously withdrew and not just allowed us to continue, but gave us warm encouragement. The completed building, now called the Tuwaiq Palace, and used for government and diplomatic functions, is seen as one of the major landmarks of the region. It is described in Patterns 1.

Based on the considerable success of the Diplomatic Quarter, the Bureau for the Diplomatic Quarter were appointed planners for the city as a whole, and its name changed to The Arriyadh Development Authority. It set about attacking the whole range of problems which had arisen from the immense and rapid growth of the city. Prime among these was the loss of identity and importance of the Kasr Al Hokm district, the heart of the original old walled city. The Authority held an international design competition for a number of the most important elements of the city centre. Padraic Kelly and others describe these projects in some detail in this issue of Patterns.

All of the partners of Buro Happold and very many of the staff have at some time or another worked on Saudi Arabian projects, either working from our head office in Bath, or in Saudi Arabia. Two partners who have committed large periods of time in Saudi Arabia are Eddie Pugh and Padraic Kelly. Eddie Pugh was resident engineer for the King Abdul Aziz sports centre, he was site project manager for the Diplomatic Club, and he later went back to manage the construction of the GCC Conference Centre with the Arriyadh Development Authority, when its construction programme had slipped so much that it would very likely not open in time for the scheduled GCC conference. The programme was accelerated and the works managed by setting tasks each morning with each of the contractors, and the project opened on time. Padraic Kelly was at first on site for the Kocommas initial works contract, returned to work on the Diplomatic Club, returned to site manage the Dirah Souq in the Kasr Al Hokm district, and returned again to be Project Manager on site for the Kasr Al Hokm district redevelopment itself. It was Padraic Kelly who opened our design and project management office in Riyadh, which has handled such projects as Half Moon Bay

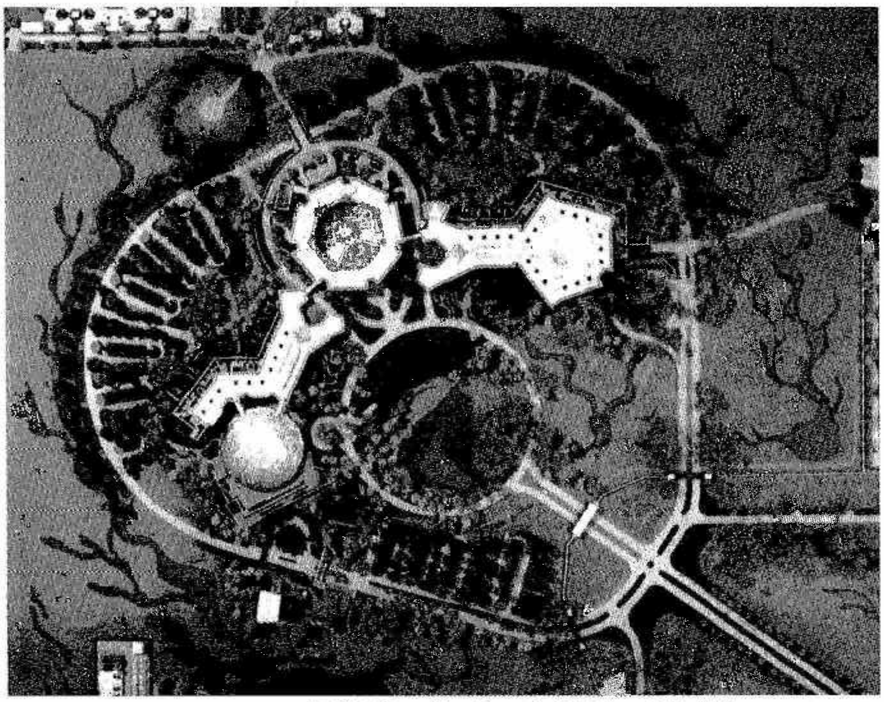


Fig 1.14 Kings office, Council of Ministers, Majlis Al Shura - model, 1976

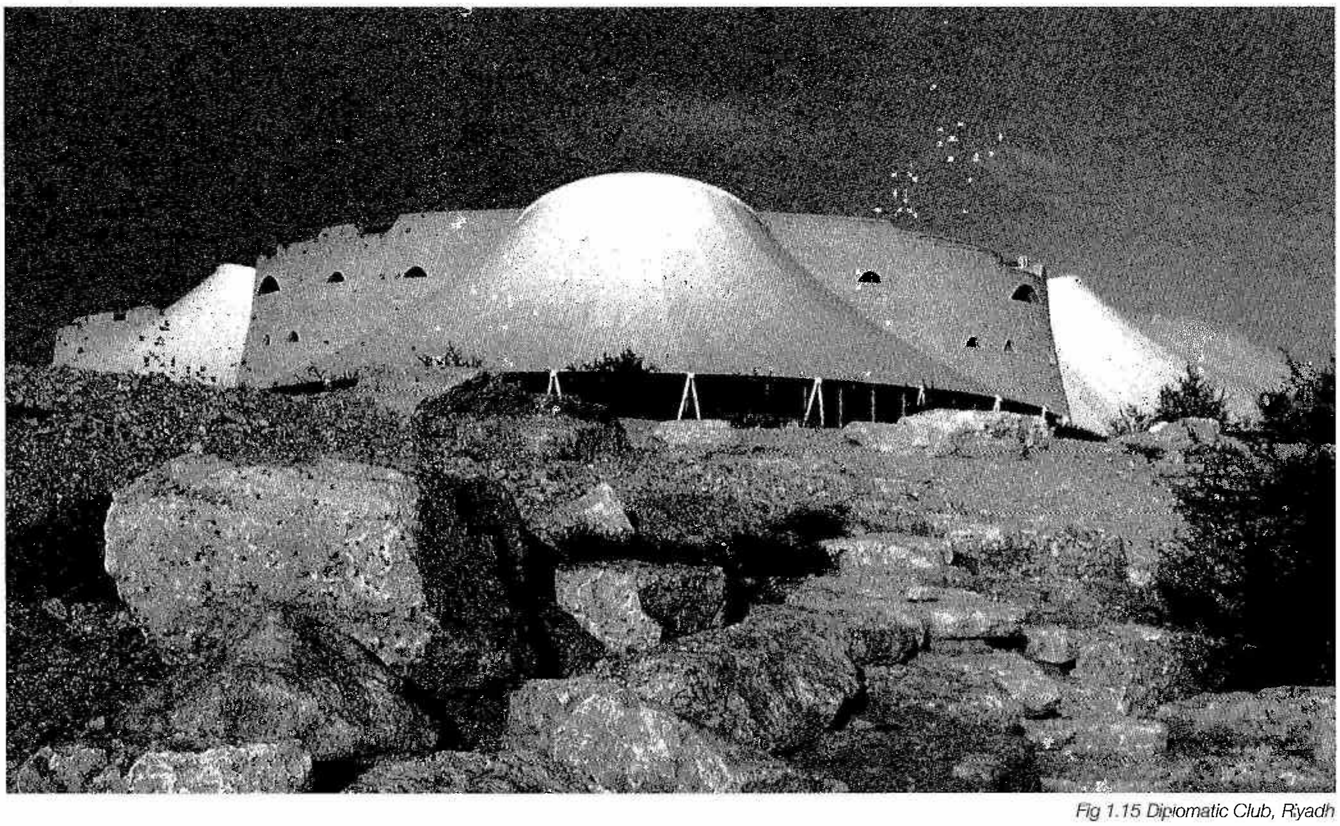


Fig 1.15 Diplomatic Club, Riyadh

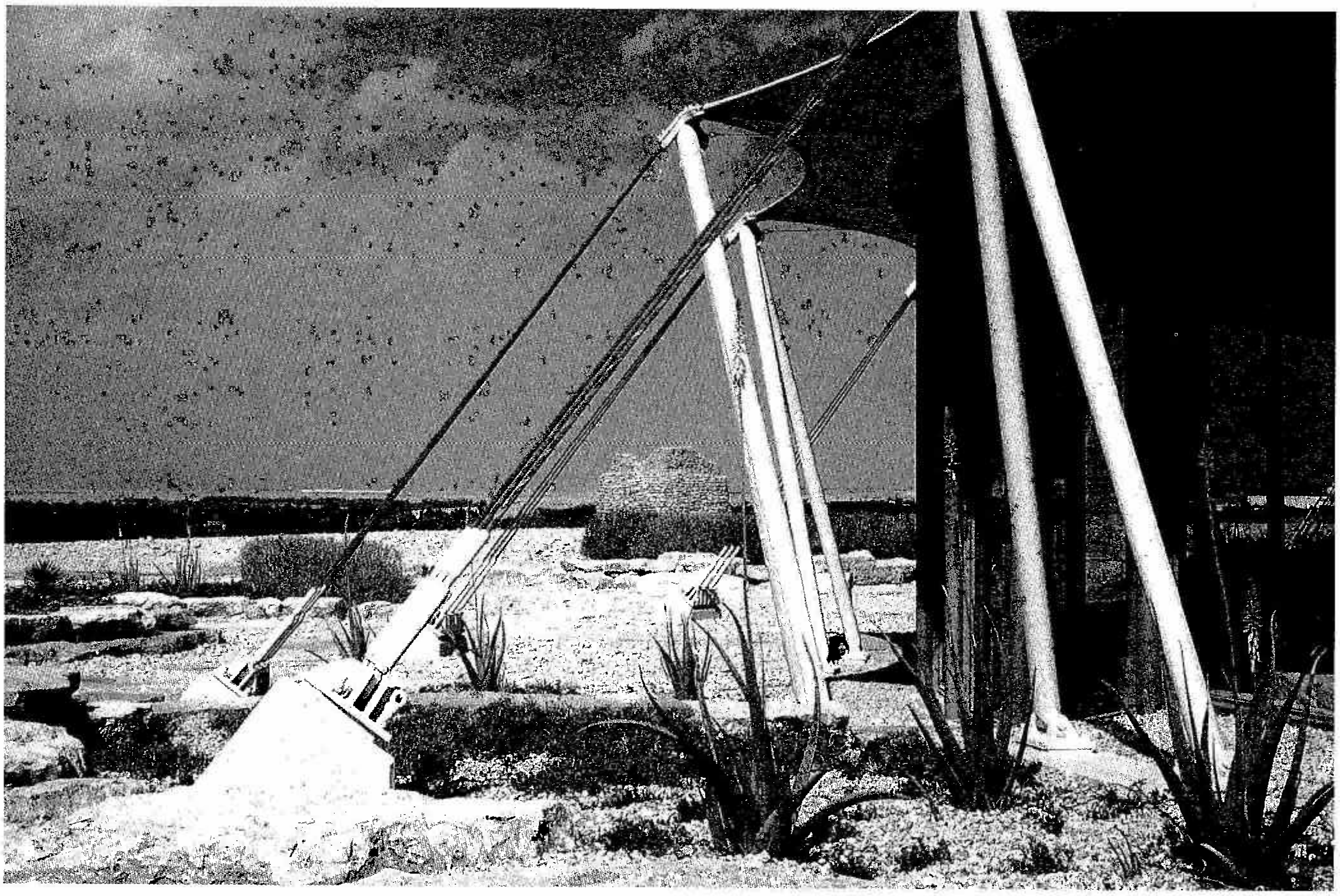


Fig 1.16 Diplomatic Club, Riyadh

(see this issue of Patterns), the Al Salam aircraft maintenance facility and the As-Samman sub-station network upgrade in the Eastern Province for SCECO.

We continue to work for the Arriyadh Development Authority and are currently working from the Riyadh office on the traffic and urban study for a city east-west main access route to relieve congestion on the Mecca road expressway.

I have not by any means mentioned all of the major projects we have carried out in Saudi Arabia, let alone the total list. I could have referred to our sports work, for example the ADF stadium and sports hall in Jeddah (Patterns 1). I should have referred to the many other mosques on which we have worked, in particular the Quba mosque, one of the most important mosques in Islam, which is also described in this issue of Patterns. This introductory article to Patterns 11 has been about working in Saudi Arabia. But we have worked throughout the Gulf, Kuwait in particular, and many other countries in the Middle East, such as Egypt and Jordan. All our work in the Middle East has been important to us. I did not include it all here because I could not do justice to it all at one time. The list is long, and the achievement for Buro Happold and for all those concerned is considerable.

I have worked in Saudi Arabia for nearly 30 years, most of which has been with the same people. It has been exciting and fulfilling for both me and my colleagues. We have met and worked with so many talented and able people from that country and we have found amongst them many friends.

Ted Happold

The Kasr Al Hokm District Redevelopment

When, in 1902, Abdul Aziz Al Saud set out for Riyadh from Kuwait with around 40 followers, his destination was a walled city measuring little more than 700m across its largest axis. With the capture of the Musmak Fort, within the Kasr Al Hokm district of the walled city, Riyadh fell to his control, and the foundations of the modern Saudi Arabian state were laid.

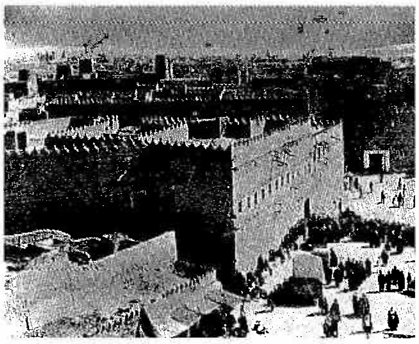


Fig 2.1a Riyadh during the 1920s

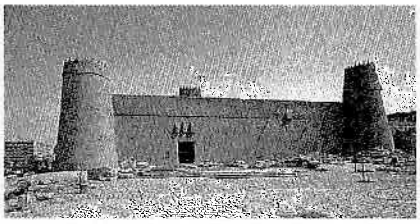


Fig 2.1b Musmak fort within Kasr Al Hokm district

'Kasr Al Hokm' means 'Palace of Justice' and the Kasr Al Hokm district was at that time the hub of administrative, commercial and religious functions of the city of Riyadh. It contained the Kasr Al Hokm itself, the Grand Mosque, the Musmak fort, and the city bazaar (or 'Souk') *(Fig2.1 a, b)*. Riyadh remained thus as a small walled city until the 1950s, which saw the start of an expansion resulting today in a metropolis comparable in area with that of Greater London, albeit less densely developed and populated. During this period of expansion the Kasr Al Hokm district declined in importance while suburban commercial areas, with their cheaper land prices, wider and better roads and modern infrastructure, reaped the benefit of the city's growth. The centre of commercial activity shifted towards the city's northern suburbs as the historical city centre suffered from a congested road network, dilapidated buildings and outdated utility networks inadequate for modern development. By the early 1980s the decline of the Kasr Al Hokm district had reached the point where visitors to Riyadh were largely unaware that it was indeed the city centre.

Fig 2.2 City centre during early construction of Kasr Al Hohm development

Redevelopment plans for city centre

With the aim of consolidating on the immense growth of the city while redressing the imbalance in its development, the Ar-Riyadh Development Authority (ADA) under the direction of Dr Mohammed Al Sheikh, embarked on a major scheme to redevelop the centre of the city. This called for new central administrative and religious buildings, with a modern infrastructure and extensive landscaping, around which private commercial development would be encouraged to take place under the guidance of the ADA.

The first phase of the city centre redevelopment included the construction of the new Emirate, Municipality and Police Headquarters, completed in 1985 at a cost of SR 420m, and the Dirah Souk, a two storey shopping and financial complex developed privately by the Saudi Real Estate Company (SRECO) and finished in 1987 at a cost of SR 75m. Buro Happold's first involvement in the Kasr Al Hokm district redevelopment was as site managers and construction supervisors for the Dirah Souk *(Fig 2.3)*.

During the autumn of 1984 an international design competition was held for the planning and design of the second phase of the city centre redevelopment. This involved the three major public buildings - the Justice Palace, the administrative seat of the Governor of Riyadh; the Grand Mosque, the main city mosque; and the Cultural Centre -

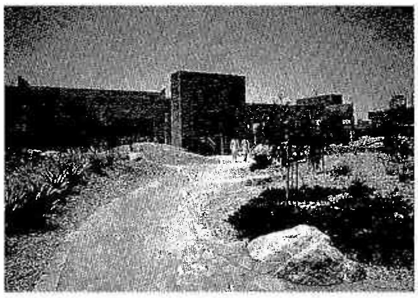


Fig 2.3 Dirah Souk after completion

together with adjacent projects and landscape and infrastructure for an area of approximately 100 hectares - and the city walls and gates *(Ref 2.1,)* and the smaller commercial projects of Safa Souk and Eastern Commercial Souk. Buro Happold were selected to act as engineers and project managers for the design of the three major public buildings, working with architects Shubeilat Badran Associates from Jordan, Scott Brownrigg & Turner from the United Kingdom and Al Shathry from Saudi Arabia. Saudconsult and BBW&P were appointed for the landscape and infrastructure project. The Safa Souk was also designed by Saudconsult, Eastern Commercial Souk by Zuhair Fayez Associates and the City Wall and Gates by Beeah. Designs were completed simultaneously over the next year and a common tender date in July 1986 was achieved. Throughout the design, regular meetings were held by a consortium of the consultants, to ensure compliance with

Project Data

Client	Ar-Riyadh Development Authority acting for the High Commission of Ar-Riyadh and commercial companies
Designers	
Justice Palace	Buro Happold, Shubeilat Badran Associates
Grand Mosque	Buro Happold, Shubeilat Badran Associates
Cultural Centre	Buro Happold, ACE, Scott Brownrigg & Turner
Landscape and Infrastructure	Saudconsult
Eastern Commercial Souk	Zuhair Fayez Associates
Safa Souk	Saudconsult
City Walls and Gates	Beeah

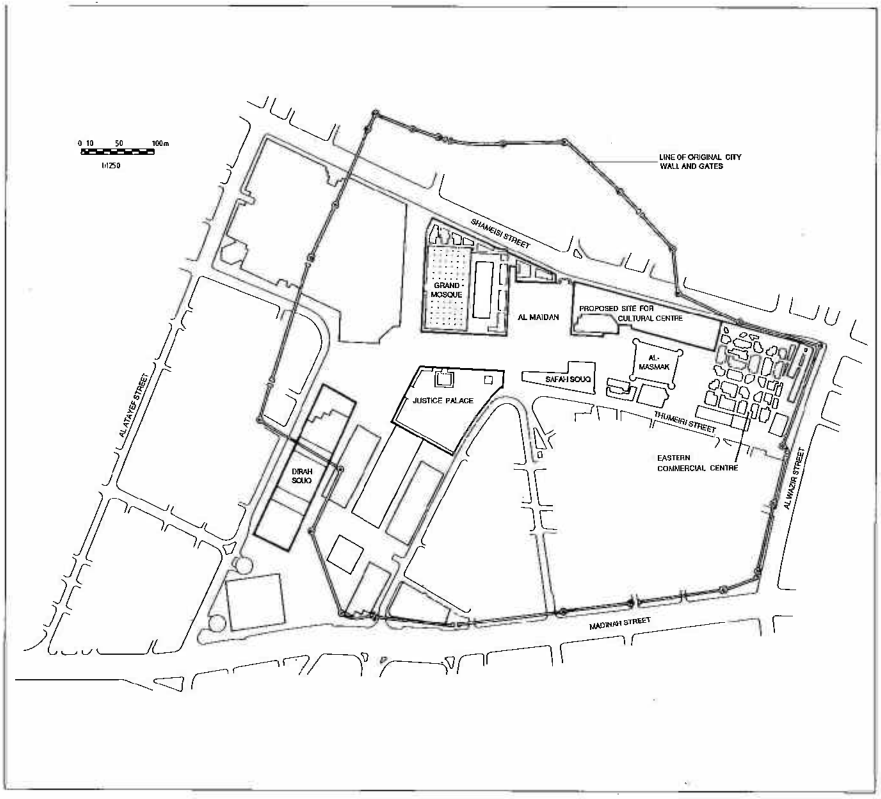


Fig 2.4 Phase 2 of city centre redevelopment showing Justice Palace, Grand Mosque, Souks and Cultural Centre

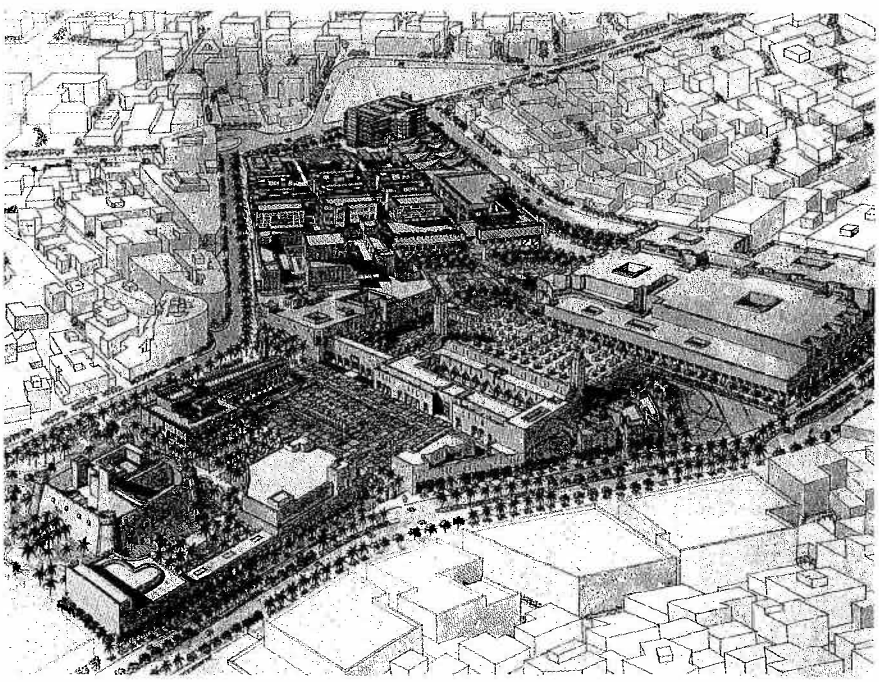


Fig 2.5 Architects' Perspective

urban design criteria and compatibility of specifications.

Phase 2 of Kasr Al Hokm programme

Justice Palace

The Justice Palace enclosing 35,000m² on seven levels is comprised of offices, reception rooms, Royal Majlis and Dining Hall, and offices for the King and for the Governor of Riyadh .The architecture follows the traditional Nejd style of the Central Province, incorporating internal courtyards, light wells and niches - these features being cleverly used to integrate the air conditioning system necessary for a modern building. Doors are traditional large wooden structures with inlaid brass. The external facades of the building and interior courts are clad in Riyadh limestone with a combination of bush hammered and honed finishes. Internal wall finishes comprise marble, gypsum or stone with various combinations of these materials used to provide rich textures. Ceiling finishes are either decorative gypsum or wood with inlaid brass, floor finishes are generally composed of intricate patterns of marble or granite in honed or polished finish and other less important areas are carpeted. Ceremonial areas are fitted with specially designed and woven carpets expressing traditional patterns translated into a modern format.

Grand Mosque

The Grand Mosque, or more correctly Jamea Al Imam Turki Bin Abdulla, is designed to accommodate 16,500 worshippers. It encloses 37,000m² of floor area and comprises a men's prayer hall for 9,000 worshippers, a women's prayer hall for 1,500, a partially covered courtyard for 6,000 worshippers, libraries, housing for the Imam and Muezzin and offices for the religious authorities. The Grand Mosque of Riyadh has traditionally been very much part of the community's commercial as well as religious life and to maintain this a number of small shops' have been integrated into the ground floor. The design and construction of the Grand Mosque are described in more detail in the following article of this journal. The external facades are clad with Riyadh limestone, incorporating details similar to those of the Justice Palace .

Cultural Centre

The design for the Cultural Centre incorporated library, auditorium, exhibition areas and administrative offices on four levels with a total floor area of 32,500m². The architecture of the building is essentially

Project Management	Buro Happold, Shubeilat Badran Associates, Saudconsult with Ar-Riyadh Development Authority	
Contractors		Contract value (SR)
Justice Palace	Dumez	188m
Infrastructure and landscaping	Dumez	118m
City Walls and Gates	Dumez	7m
Grand Mosque	Keang Nam Enterprises (formerly MABCO)	141m
Safa Souk	Keang Nam Enterprises	18m
Eastern Commercial Souk	Saruc	25m
Final Completion Date	Spring/Summer 1992	

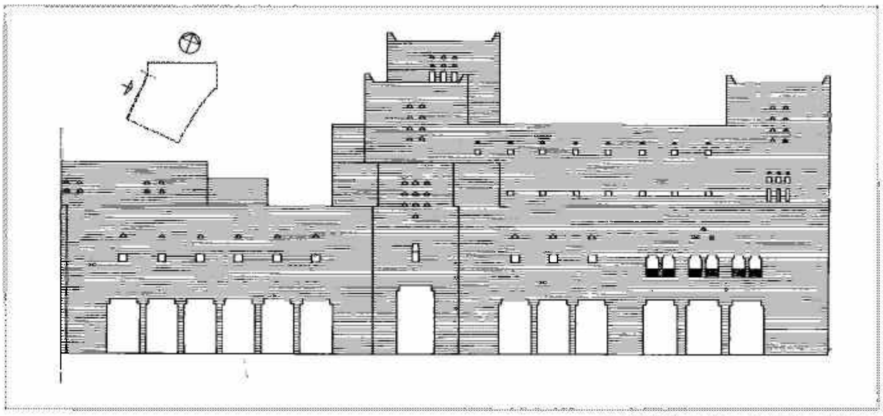


Fig 2.6 Elevation of Justice Palace

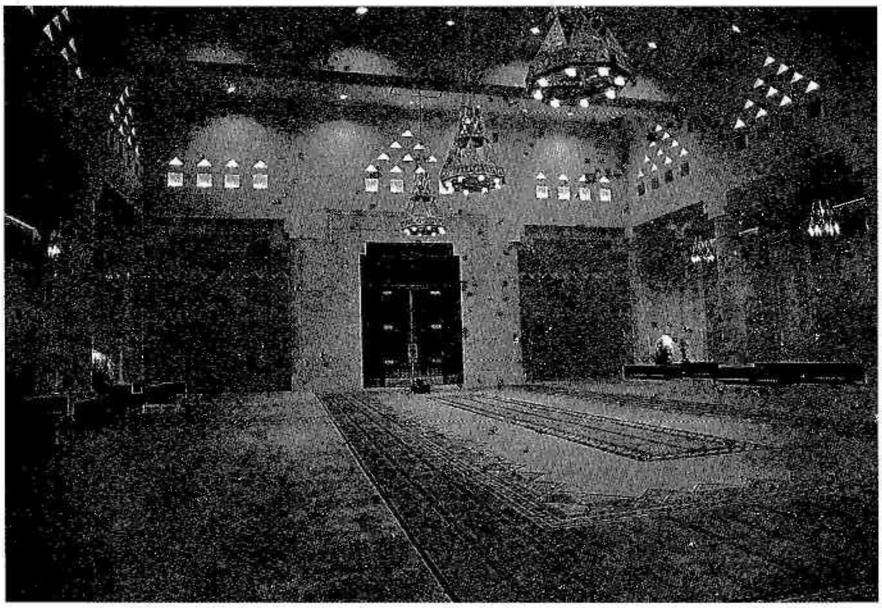
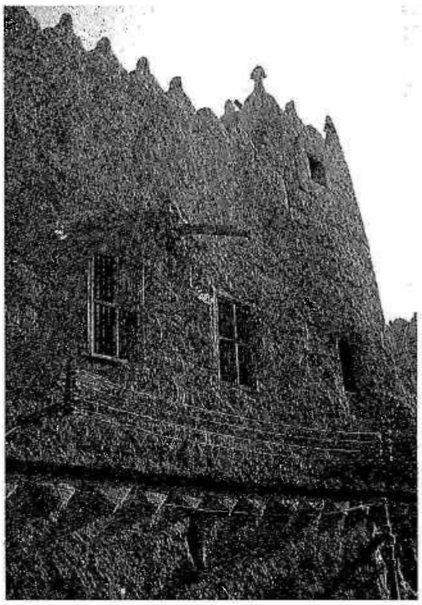


Fig 2.7 Interior of completed Justice Palace



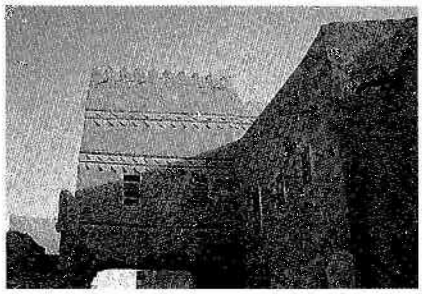


Fig 2.8 a, b Traditional Nejd architecture - and early adobe buildings, Riyadh

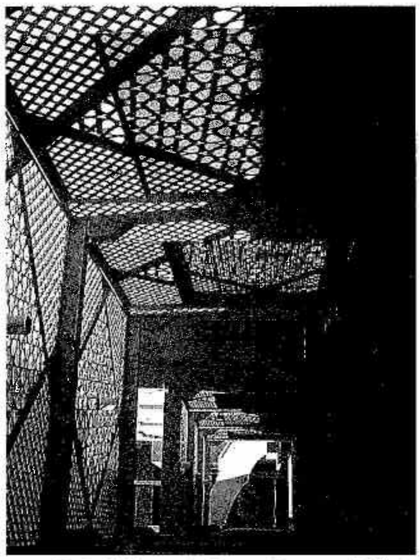


Fig 2.9 Alleyway in Eastern Commercial Souk

modern but enclosed within a Riyadh stone screen wall generally following the Nejd style of the external facades of the Justice Palace and Grand Mosque.

Eastern Commercial Souk

The Eastern Commercial Souk, at the eastern perimeter of the Kasr Al Hokm district, is a single storey development of shops for small traders, planned along traditional lines as a series of interconnecting shaded alleyways *(Fig 2.9)*. This souk, comprising a total floor area of 12,500 m² is principally a ladies' souk, with many of the shops selling clothes and materials.

Safa Souk

The Safa Souk, to the east of the Grand Mosque and Justice Palace, forms the southern perimeter of 'Al Maidan', literally translated as 'the square'. Al Maidan is enclosed on its north and west perimeters by the Grand Mosque, and by the Cultural Centre site to the east. The Safa Souk is a two-storey shopping complex of 9,700 m² floor area accommodating a department store on the ground floor.

Infrastructure and Landscaping

The infrastructure and landscaping works have involved the development of largely new infrastructure, provision of potable and waste water, irrigation, electricity and

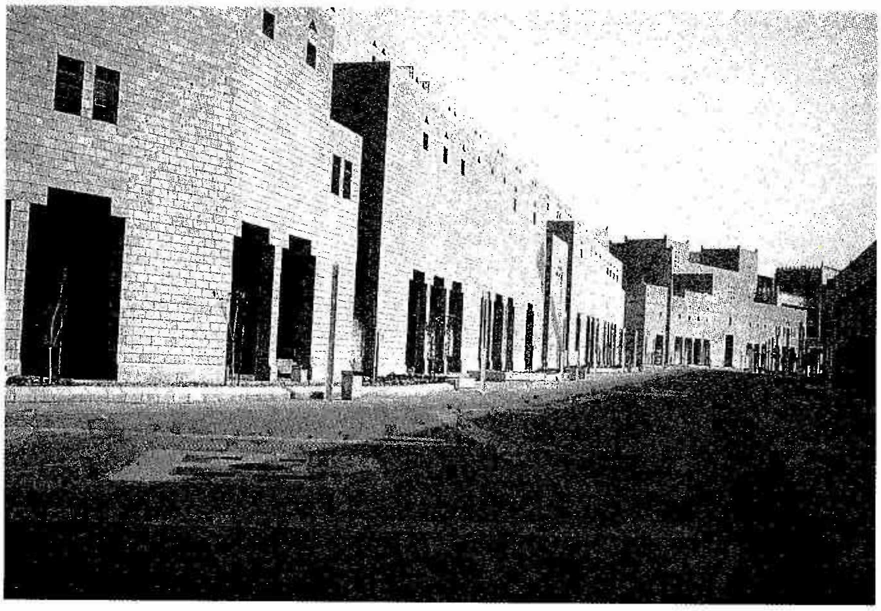


Fig 2.10 Street facade of Kasr Al Hokm

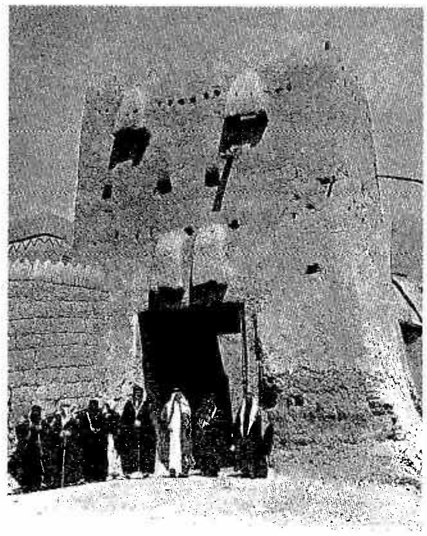


Fig 2.11 Original City Wall of Riyadh (photo: Philby)

telephone utilities, and the construction of 20km of new roads and associated sidewalks, with more than five hectares of granite paved areas and associated landscaping. This has proved an extremely complex task in an old city centre souk area where accurate records or as-built drawings of many of the existing utilities are not available. Work had to be co-ordinated with all of the utility agencies and in the existing conditions it was difficult and in some instances impossible to simultaneously satisfy all parties. Typically a stretch of 1km of road required six to nine months to complete.

City Walls and Gates

As part of the redevelopment of the city centre, the Ar-Riyadh Development Authority (ADA) wished to establish, record, and where possible, reconstruct the old city walls and gates which had been lost in the rapid development of the city *(Fig 2.11) (Ref 2.1)*.

A construction management team approach

It was clear that the construction of the major public buildings in the Kasr Al Hokm district would require considerable relocation of, and disruption to the existing commercial area. To ensure that commercial activity was maintained throughout the construction period of the major projects, the ADA decided with the assistance of a local private developer, to firstly construct the Dirah Souk and the adjacent Al Mamoun Street, as part of the Phase 1 redevelopment of the Kasr Al Hokm district. These were completed in 1987, well ahead of the Phase 2 works.

The SR 500m Phase 2 projects were competitively tendered, with nine contractors, including some of the largest Saudi and foreign contractors operating in the Kingdom, completing tender documents. After initial budgetary delays, contracts were signed in March 1988. Dumez, a French company, was awarded contracts for the Justice Palace, landscape and infrastructure and the city walls and gates. Manufacturing & Building Company (MABCO), a local contractor, was awarded the Grand Mosque and Safa Souk, while Saduc, a local company, was awarded the Eastern Commercial Souk. The ADA decided against proceeding at this time with the Cultural Centre but chose to retain a more open aspect to the Musmak Fort which is now being used as a national museum.

ADA policy on site management and supervision is to set up an owner's representative organisation. The consultant is not employed to execute the contract as 'the engineer' or 'the architect', but rather to act as the owner, and letters and instructions to the contractors are issued on the ADA's own letterhead. With the Kasr Al Hokm district redevelopment, a number of consultants had been involved in the design, and it was naturally deemed desirable that some of these continue to be involved in the construction stage. Buro Happold were appointed to set up a management and supervision team together with ADA professional staff, supported by architects and engineers from some of the building and infrastructure design teams. Buro Happold filled the key positions of project manager, co-ordination engineer, and a number of the senior civil, structural, mechanical and electrical engineers and quantity surveyors. The ADA fielded a number of key engineering and architectural positions and in addition architects were drawn from the Mosque and Justice Palace designers, while the infrastructure and landscape designers provided personnel for landscape and infrastructure engineering roles. The ADA were represented on site by the Kasr Al Hokm project director, Ibrahim Sultan. Co-ordination of the team fell largely to Buro Happold, and essential computer systems were set up for monitoring and control of correspondence, shop drawing and material submittals, queries, inspection procedures and the many other aspects of site supervision and management. A project procedures manual was produced and distributed to all members of the team.

Co-ordination of the various contractors has been achieved by a detailed involvement from each at weekly progress and co-ordination meetings. The situation was not without its difficulties, particularly as each contractor worked to meet his scheduled completion date in a gradually reducing working space. A particular problem was experienced with the Al Megleya Commercial Centre, being developed by the Al Megleya Company. This project is located adjacent to the Mosque and Justice Palace and was being constructed concurrently. Due to difficulty in relocating existing tenants, demolition and construction of the last section of this project was late and prevented simultaneous completion.

Commencement of construction

The generous construction schedule of three and a half years was dictated mainly by funding requirements and the ADA's determination to maintain commercial activity as far as possible within the city centre during the construction period. Contractors commenced mobilisation in April 1988.

One of the contractors, MABCO, went into liquidation in December 1989 and consequently the Grand Mosque and Safa Souk projects were assigned to the Korean subcontractor, Keang Nam Enterprises (KNE). MABCO continued, however, to function as a precast supplier, supplying all precast elements.

The build up to, and the duration of the Gulf War, affected the progress of the works, with various contractors experiencing difficulties in labour and material availability, particularly with imported materials. Prior to the war, few believed that scud missiles had the capability to land in Riyadh and consequently the first few days after the first missile attacks were very tense. ADA staff and the site management and supervision team continued to work normally throughout the build up to the war and during hostilities. The effect was to provide encouragement and reassurance to the contractor's staff and labour, and by and large there was continuity of work, albeit with considerably reduced output. However, in common with most projects in the area, no site work was executed for a number of days immediately following the outbreak of hostilities. With the reduced frequency of scud missile attacks, projects gradually returned to normal. The Grand Mosque and Safa Souk projects were affected to a greater extent than the Justice Palace and landscape and infrastructure project.

The Eastern Commercial Souk was completed at an early stage of the Phase 2 works, in spring 1990. This enabled traders principally from the ladies' souk to be relocated, thereby enabling landscape and infrastructure works of the new large open pedestrian plazas to proceed. The Grand Mosque and Justice Palace were completed in February 1992, and formally opened by King Fahad Bin Abdul Aziz Al Saud on 10th March 1992.

Padraic Kelly, Terry Ealey and Rodger Webster

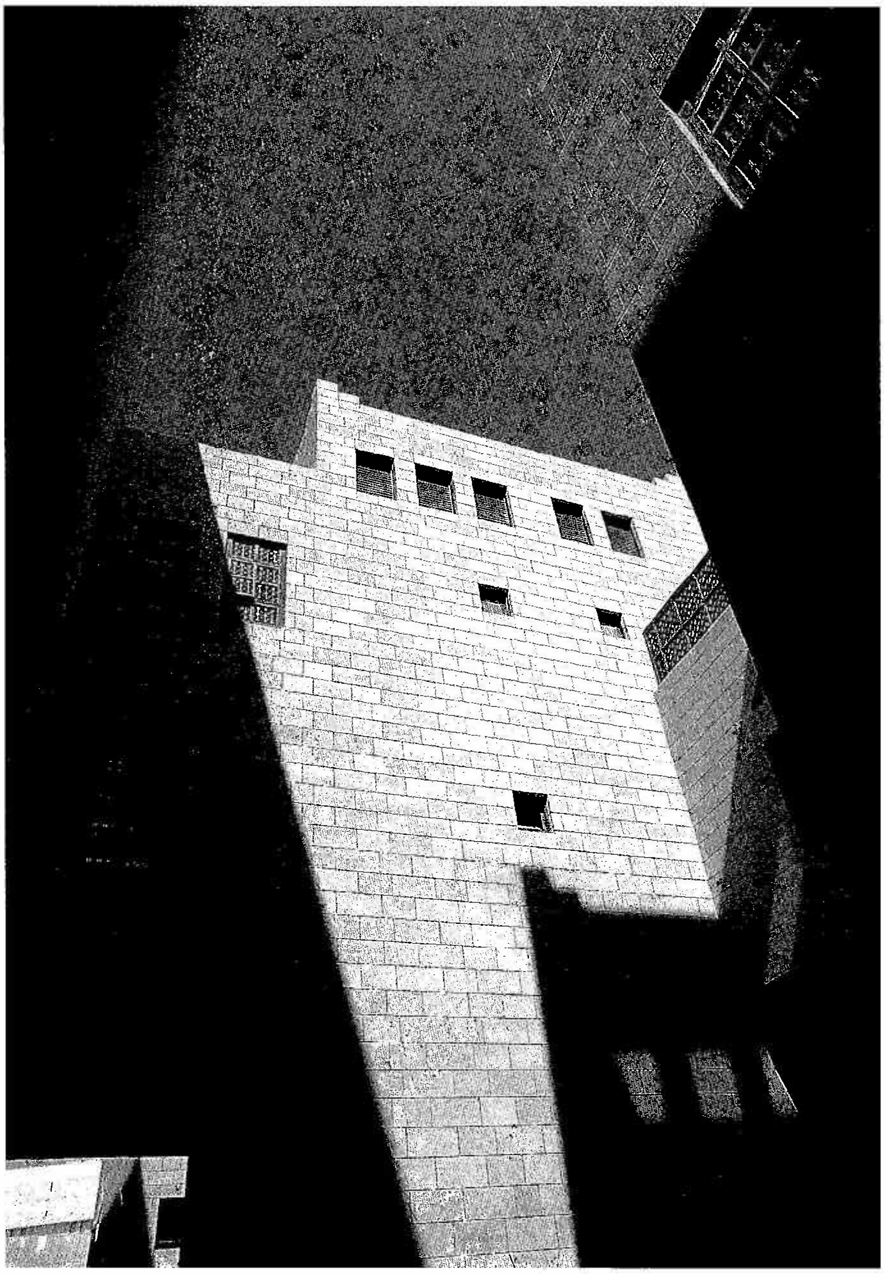


Fig 2.12 Alleyway at side of Souk

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The Grand Mosque, Riyadh - Jamea Al Imam Turki bin Abdulla

Project data

Client	Ar-Riyadh Development Authority
Architect	Shubeilat Badran Associates
Structural Engineers	Buro Happold
Services Engineers	Buro Happold
Completion date	February 1992
Project cost	SR 141 million

Fig 3.1 Street Scene, Riyadh, in the 1920s (photo: Philby)

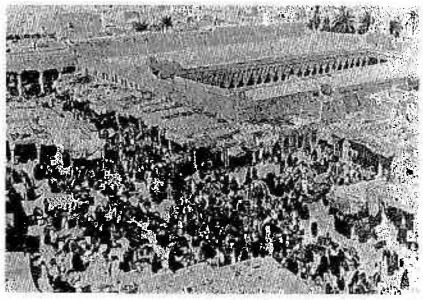

Fig 3.4 Original Grand Mosque (photo: Philby, 1922)

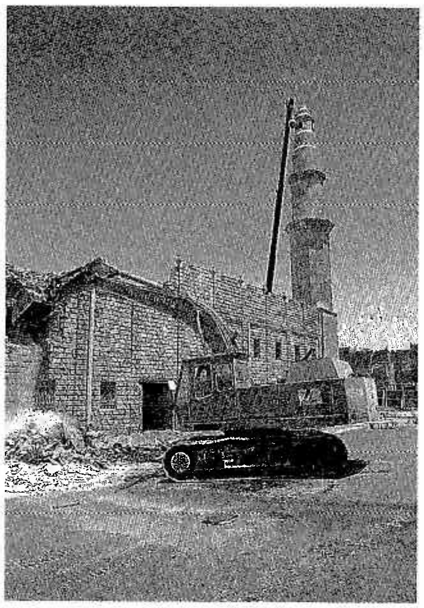

Fig 3.5 Demolition of 1950s mosque

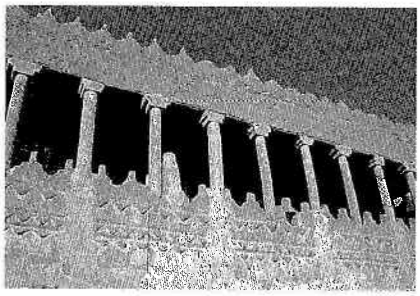

Fig 3.2 Traditional Nejd architectural style

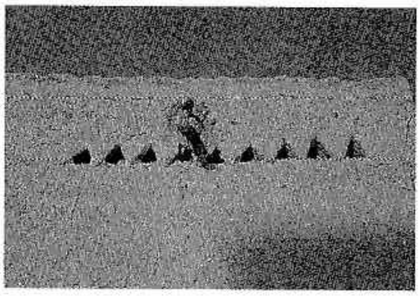

Fig 3.3 Facade with triangular openings

Riyadh, the capital of Saudi Arabia, is also the capital of the Central Province, or Nejd region, of the country. Traditionally, buildings of that region were constructed with heavy adobe mud walls, and roofs of tamarisk poles decked again in adobe mud, reinforced with tamarisk twigs on a base of palm leaves. Where longer roof spans were needed, palm trunks were introduced as main beams supporting the tamarisk poles which in turn acted as secondary beams. In all but the more simple domestic dwellings, walls were constructed at the base with three or more courses of limestone masonry, so preventing water scour during heavy rains.

To form a shaded space to the side of a building, the adobe mud roof was supported on palm trunks spanning between plastered limestone masonry columns, with column heads either providing support to the beams or to triangular masonry arches. The nature of the mud, stone and wood beam construction generated an architectural style characterised by heavy walls, columns and column heads, with openings which were either square or triangular in form. Decoration followed these forms, with triangular motifs sculpted into the adobe walls, and crenellated roof parapets *(Figs 3.2 and 3.3)*. Wooden over-flow spouts projected from the structures to take roof water run-off clear of the buildings thereby ensuring minimal rainwater erosion of walls.

Traditional mosque construction

Mosques of the region were constructed in the same architectural style. The high spaces of prayer halls were formed by a grid of columns supporting tied masonry arch walls above, which in turn supported a wood and adobe roof. Masonry arch walls were tied by either wood beams or, later, steel rods. The grid of columns was related to the rows of worshippers facing the Qibla wall, with column spacing limited by the span of roof and tied arch walls. The choice of heavy mass construction materials minimised diurnal internal temperature changes, while the large air volume of the prayer halls absorbed the rapid heat build up occurring when the prayer hall filled with worshippers.

The original Grand Mosque of the old walled city of Riyadh was very much in the traditional style of the Central Province, and was in existence when Palgrave prepared an early map of the city in 1865 during his journey through Central and Eastern Arabia *(Ref 3.1)*. The mosque can also be seen in the photographs of St John Philby, taken around 1922 *(Fig 3.4)*. As expansion of the city commenced, the original mosque was

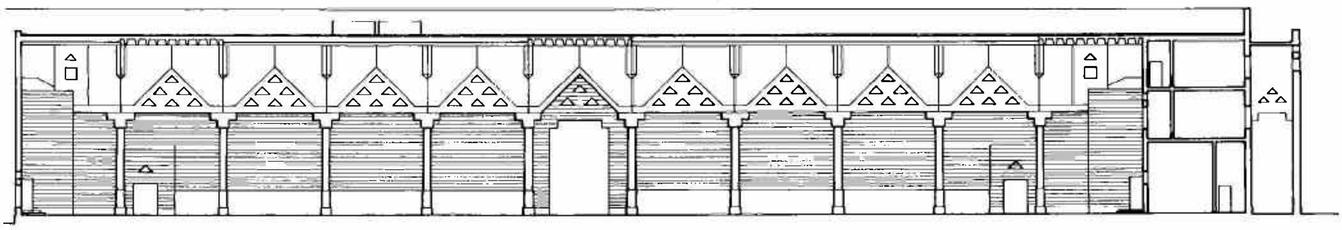

Fig 3.6 Section through Grand Mosque

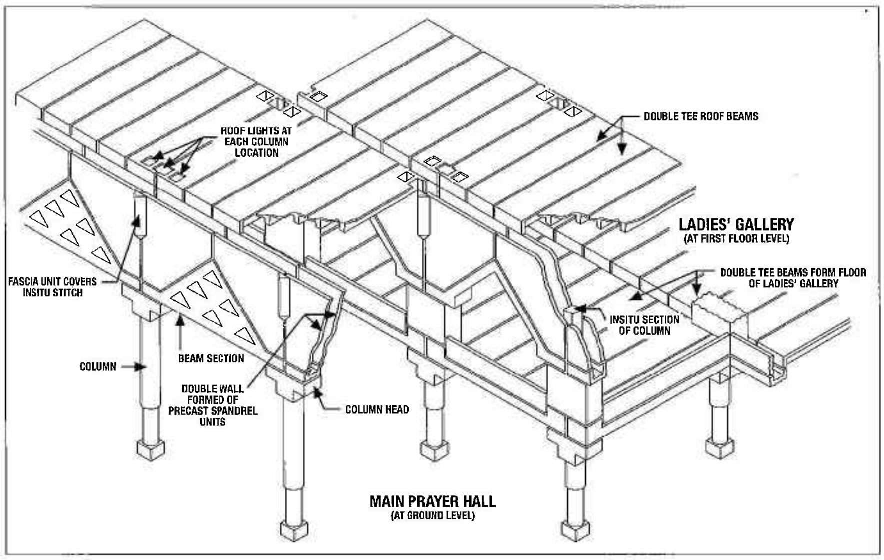

Fig 3.7 Isometric through mosque showing arch, beam, column and roof structures

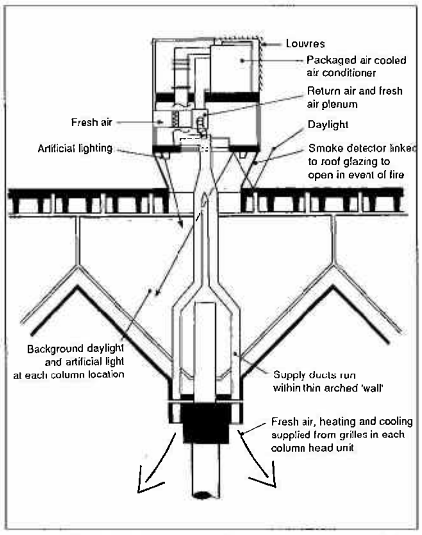

Fig 3.8 Section through column showing principles of environmental roof unit

replaced in the 1950s by a mosque clad in imported light coloured stone *(Fig 3.5)*. This 1950s mosque was of reinforced column, beam and slab construction but whilst serving its purpose, was of unfamiliar, perhaps even placeless, style. Furthermore, in contrast to the apparently correct orientation of the original Grand Mosque, the 1950s mosque was orientated 20 degrees skew from the Mecca axis.

The 1980s refurbishment programme

From the 1950s the city centre declined in importance both culturally and commercially, until the mid 1980s when the Ar-Riyadh Development Authority set about reversing the trend by instituting a major programme of refurbishment and reconstruction. Work on infrastructure and public buildings was to be undertaken by the public sector, while new commercial developments would be built by private developers. The building of a new Grand Mosque was to be included in this redevelopment programme.

A competition was held for the design of the new Grand Mosque, and in 1985 the Ar-Riyadh Development Authority appointed the opposing teams of architects Shubeilat Badran Associates and engineers Buro Happold for the project. The Authority saw a strong precedent for appointing opposing teams, as they had previously joined Frei Otto and Buro Happold together with Omrania for the successful Towaiq Palace (Diplomatic Club) *(Ref 3.2)* in the diplomatic quarter of Riyadh, after a similar competition some years previously.

The concept design *(Fig 3.6)* for the new Grand Mosque was one very deliberately in character with the traditional building forms of the Central Province. The Grand Mosque lay in the Kasr Al Hokm District, at the heart of the old walled city, and the prime objective of the redevelopment was to re-establish the area as the cultural centre of the city, visibly reflecting its historic past. The materials used in early traditional Nejd construction are not appropriate for a modern building of the magnitude of the Grand Mosque, and to have attempted to copy faithfully such construction would very likely have resulted in a form of stage set. Nor could a logical co-ordinated engineering solution be sensibly achieved when incorporating the required mechanical and electrical building servicing into such a structure.

An engineering solution

In developing an engineering solution for the building, two sets of criteria had to be met. Firstly, the building should clearly follow the forms and principles of construction, if not the materials, of traditional buildings of the region. Secondly, air conditioning, lighting and other building services should be incorporated into a structural system in such a way as to achieve a co-ordinated and logical, rather than forced, engineering solution.

A precast concrete form of construction was developed for the structure of the Grand Mosque, with columns supporting column heads and a system of double walls above, which in turn support a precast double tee beam roof *(Fig 3.7)*. The double walls have the style, form and mass of the early tied masonry arch walls, and the double tee beams give a modern textural equivalent of the early tamarisk pole and adobe roof. The precast double wall not only serves the same structural purpose as the early tied arch masonry, but can span further and provides

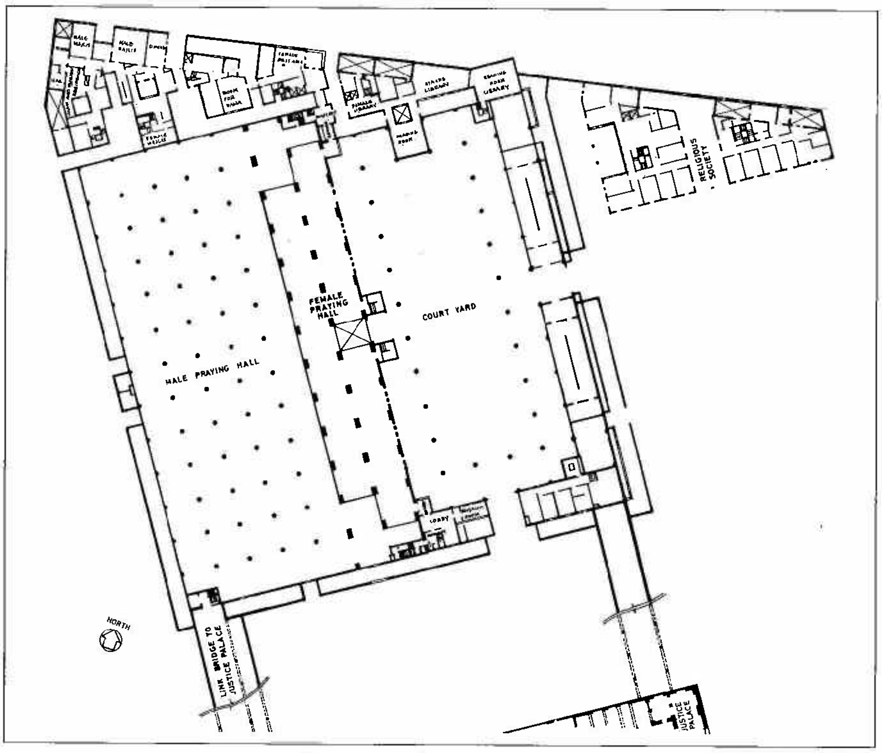

Fig 3.9 Plan of Grand Mosque showing prayer halls, courtyard and offices

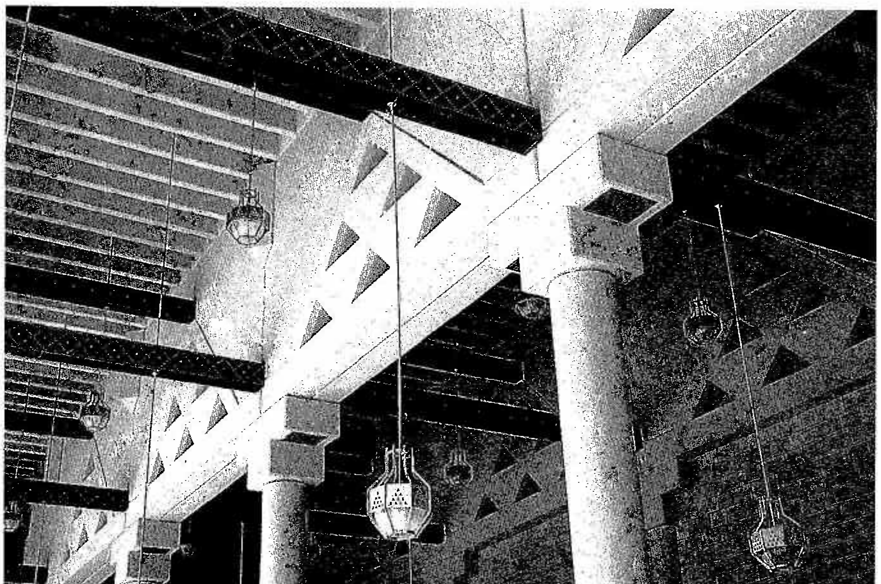

Fig 3.11 Completed precast construction of interior

space within it for mechanical and electrical servicing, in particular for cooled air, which flows within the walls and then into the prayer hall from grilles at the sides of each column head. Each column position is a co-ordinated structural and environmental unit, with a roof assembly of air-conditioning, daylighting, artificial lighting and fresh air

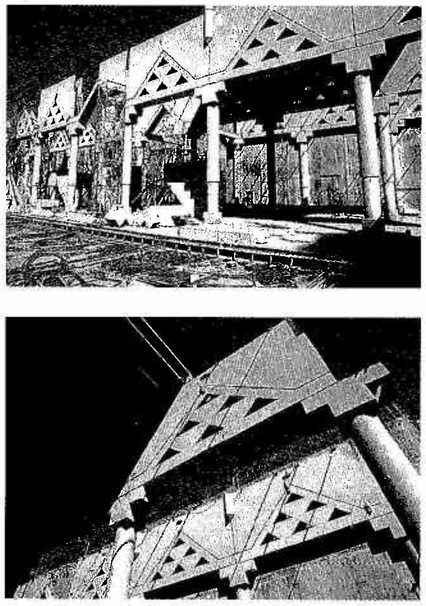

Fig 3.10 a, b Precast erection of Grand Mosque

supply *(Fig 3.8)*. Reflected daylight also enters the prayer hall at each column position, providing not only background illumination during daytime, but shafts of light to add to the interest and character of the space and its construction.

The environmental benefits of early traditional heavy mass masonry construction are retained by the mass of the precast concrete, and the 14m height of hall provides a generous air volume above the worshippers. The structural system faithfully adheres to tradition but is updated to suit the needs and methods of today by co-ordination and careful detailing. It avoids the common basic aesthetic of precast concrete construction, where the utilitarian appearance of concrete elements bearing simply on each other would lack co-ordination with mechanical and electrical building services and building finishes.

Accommodation and facilities

The 8.4m column grid of the prayer hall was chosen for its relationship to the height of the building and to the spacing of the rows of worshippers. A carpet designed and made in Riyadh with traditional patterns and colours to help the 10,500 worshippers find their praying position, covers the entire prayer hall.

The precast form of construction of the prayer hall is repeated in the open courtyard beyond edged with ablution facilities. The courtyard overlooks two minarets with

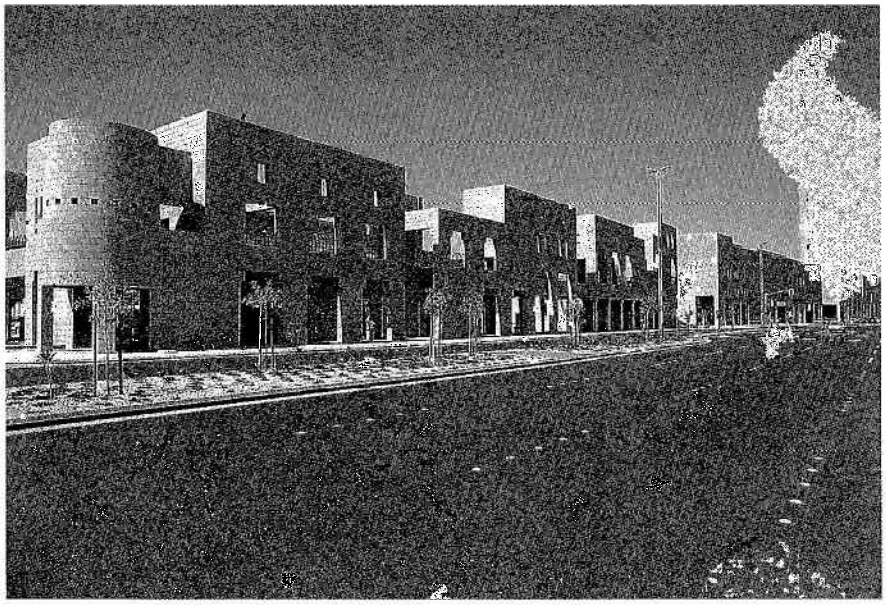

Fig 3.12 Shop units along Shemaisi Street

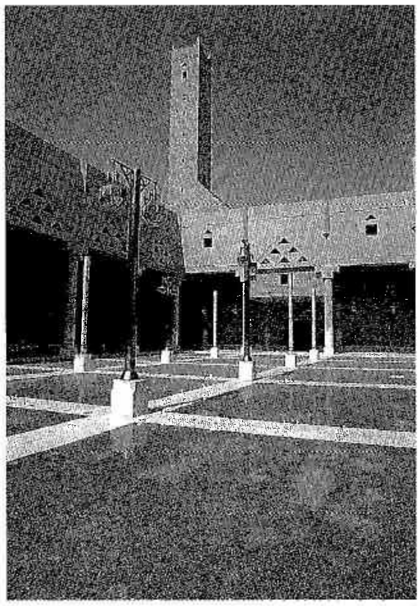

Fig 3.13 b Minaret overlooking mosque courtyard

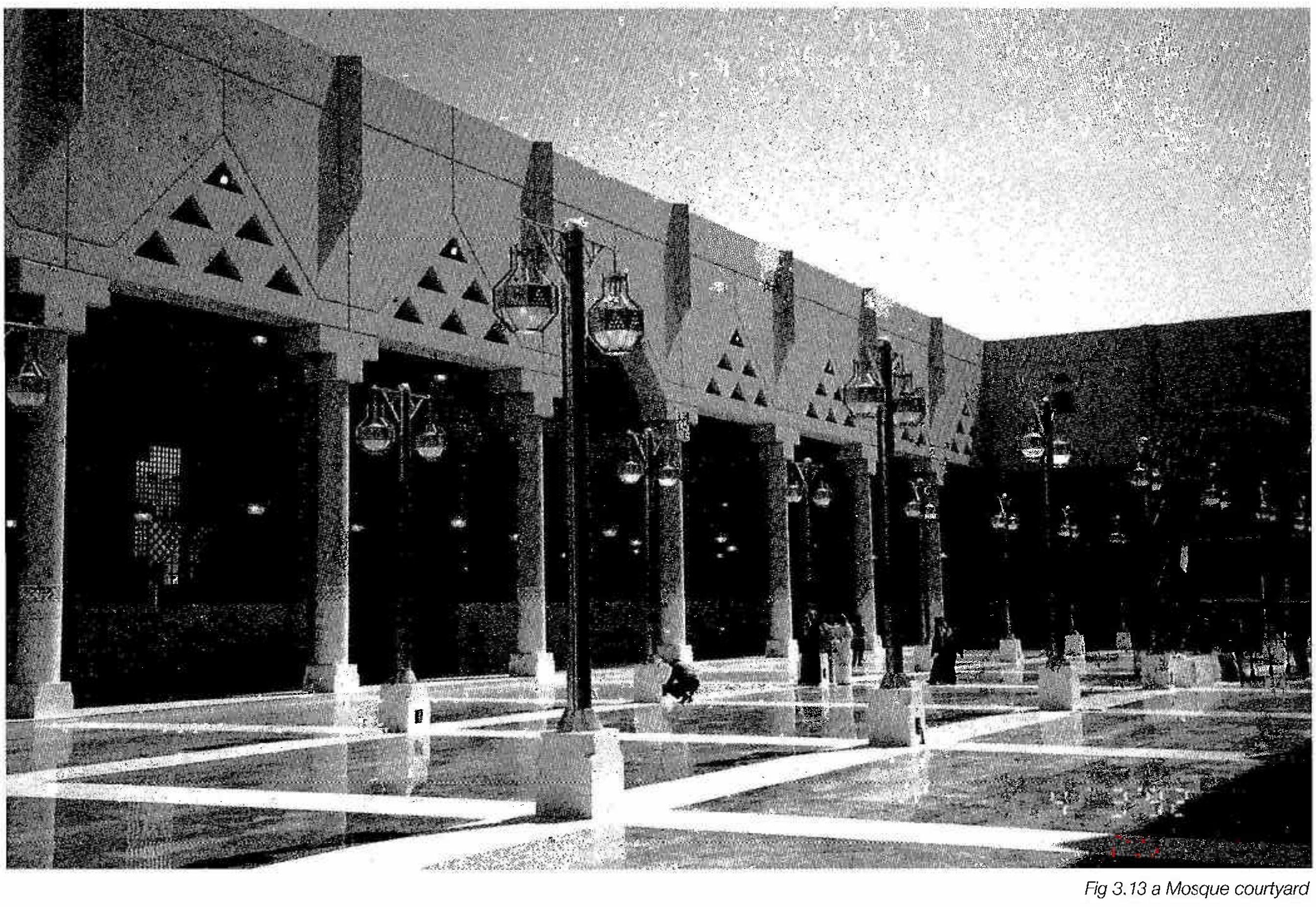

Fig 3.13 a Mosque courtyard

Fig 3.14 Interior of completed main prayer hall

sloping stairs, a feature typical of old mosques in the surrounding villages. Facilities in the courtyard allow 6,000 worshippers to pray outside, particularly in the mild season, while during the hot weather, some of the return air from the prayer hall is passed out into the courtyard, providing worshippers there with a continuous cool breeze.

In addition to prayer hall and courtyard facilities, Imam and Muezzin accommodation, library and offices are contained on the Shemaisi Street side of the mosque, generally above first floor level. Small shop units are provided at ground level on both the Shemaisi Street side and facing Al Maidan *(Fig 3.12)* so reflecting the traditional concept of the mosque as the centre of commercial as well as religious life in the city. These buildings, together with the 50m high minarets, and the external walls of the prayer hall, are of reinforced concrete.

The Hurayamala Co-operative quarries north of Riyadh provided the scabbled Riyadh limestone used to clad the external elevations, interior walls of the prayer hall and courtyard walls, so imitating the rough texture of adobe mud construction.

The Grand Mosque was opened by King Fahad in March 1992 and is in daily use, regularly drawing over 20,000 worshippers on Fridays, with the overspill praying in Al Maidan, the newly landscaped public square in front of the mosque.

Terry Ealey and Padraic Kelly

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3.2 Ealey T, Grant V, Green M and McLaughlin T 'Diplomatic Club, Riyadh' Patterns 1 pp 20-24 October 1987

Half Moon Bay - a resort complex in eastern Saudi Arabia

Project data

Client	Saudi Hotels & Resort Areas Company (SHARACO)
Designer	Zuhair Fayez Associates
Consultants	Abalkhail Consulting Engineers
Construction managers	Buro Happold Planning and Management
Project value	SR 150 million (Phase 1)
Completion date	November 1991

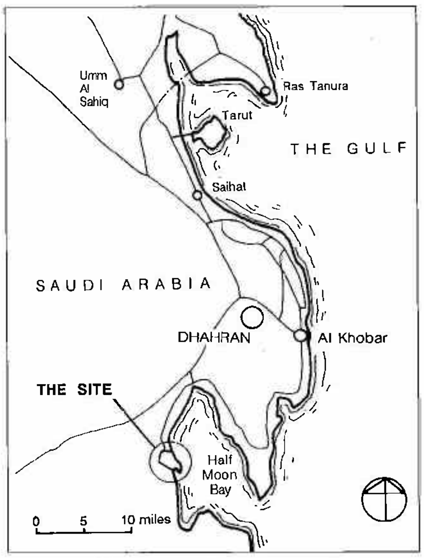


Fig 4.1 Location of Half Moon Bay indicating project site

Half Moon Bay, approximately 20km long and almost completely enclosed, is located 30 km south of the city of Al Khobar in the Eastern Province of Saudi Arabia, and is renowned as a very popular tourist resort with a number of private beach clubs and shelters provided by the Municipality. The client, Saudi Hotels and Resort Areas Company (SHARACO) selected a site for a five phase residential and marina development on the western shore of Half Moon Bay with the project formed around a smaller bay 2 km in diameter *(Fig 4.1)*.

Phase 1 concept

The project was conceived as five phases, the first of which was designed in 1986 by Zuhair Fayez with master planning and contract for the initial ground improvement carried out by Sir William Halcrow and Partners Ltd. A self sufficient resort complex of 251 luxury housing units made up of one bedroom apartments, two bedroom bungalows and three and five bedroom villas with maids quarters, was to be located in eight clusters around the bay *(Fig 4.2)*. Recreation facilities were provided, including a swimming pool at each of the five bedroomed villas, a beach club with further swimming pools, a multi-purpose sports court and a boat house with jetty leading to a floating harbour. The service area was planned to comprise an administration centre with staff accommodation and maintenance support facilities including a self contained water and sewage treatment plant.

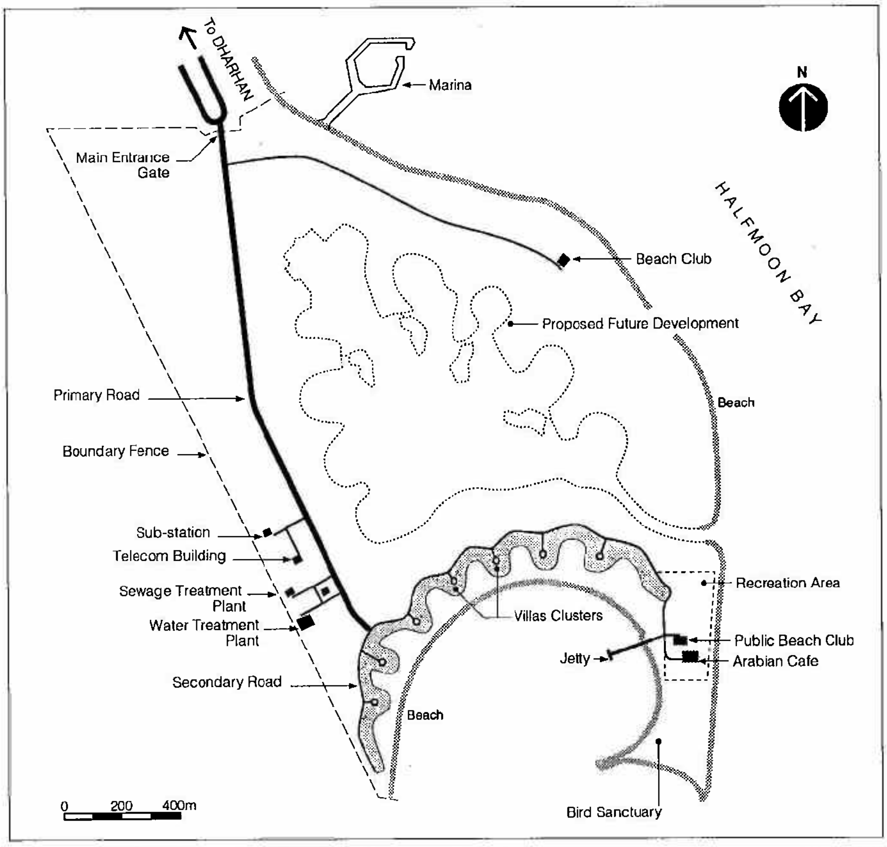


Fig 4.2 Plan showing location of apartments, bungalows and villas arranged in eight clusters around the bay

The site is both soft and hard landscaped with a network of roads and car parking. As the national telephone network was not available, the 120 channel telephone system required installation of a 50m high mast with antenna providing a microwave link across the bay to the exchange in Al Khobar. When all five phases are complete the overall development will provide further mixed housing encircling a dredged lagoon. Total value of the first phase is approximately SR 150 million, or £27.5 million at March 1993 exchange rates.

Interruption to works

The 21 month contract for construction was awarded to Manufacturing and Building Company (MABCO) after a competitive tender, and work commenced on site in June 1988. The project came to a halt in December 1989 with the liquidation of MABCO, who had completed less than 40% of the work. During the latter periods of the MABCO contract, co-ordination among the subcontractors had been poor, with a loss of construction sequence - each subcontractor trying to complete his own section of the work. When works finally came to a halt, all of the housing units had been structurally completed *(Fig 4.3)* while most of the infrastructure, including a deep sewer, was still to be constructed. Individual villas had final-fix M&E and internal joinery but no external doors or windows, a particularly significant problem given the frequent spring sand storms and the prevailing high summer humidity.

Fig 4.3 Structures following halt on work in December 1989

SHARACO Projects Department investigated a number of alternatives for restarting the

Contractors		Contract value
General works contractors	Al Wasat Contracting Company	34.88m
M&E works	Abahsain-Secem Ltd	27.63m
Deep sewerage	Civil Works Company	3.75m
Waterproofing	Al Turki Company	1.44m
Pre-engineered steel buildings	Al Zamil Metal Industries	0.51m
Roadworks	Nassir Hazza & Bros	6.13m
Aluminium works	Sanabel	3.27m
Sewage and water treatment works	Metito Industries Ltd	1.64m
Landscaping and hardscaping	Rabya	5.38m
Floating harbour	Assam Trading	1.00m
Gates and barriers	Saudi Crawford	0.05m
Fencing	Al-Derbas	0.37m
Fencing supply	Saudi Metal Industries	0.89m
Beach platforms	Shairco	0.40m
Signing	Ad/Art Medyan	0.38m
Jetty and dredging	Saudi Archirodon	2.75m
Miscellaneous		0.37m

project and in a desire to have a 'hands on' involvement in the works, selected a construction management approach. A large amount of the work had originally been subcontracted by MABCO, and most of the existing subcontractors had expressed an interest in completing the project under direct contract with SHARACO.

Construction management for 'fast-track' completion

In May 1990 Buro Happold were appointed as construction managers with a brief to achieve 'fast-track' completion of the project in one year. The original consultants, Abalkhail, were retained for quality control. With so much work out of sequence, BHPM's initial task was to devise a programme which would regain a proper construction sequence *(Fig 4.4)* and provide for the smooth and timely completion of the project. The site fell naturally into four physical areas; the villas, arranged in eight clusters; the recreation area; the maintenance area; and the remaining minor works comprising the main entrance and temporary beach clubs. Planning was carried out using MacProject, with presentation output managed by exporting the database from MacProject to AEC Information Manager. Generally the network was maintained at around 800 activities with completed items being dropped as new ones were added to provide an increasingly higher level of detail.

In parallel with production of the scheduling the remainder of the start-up team concentrated on preparing the package for the tender of the new general contract, and pursued negotiations with the original subcontractors to return to complete their works. The client however, had determined that these subcontractors would only be allowed to return to complete on acceptance of their original rates and, generally speaking, original conditions of contract. Because of the variety of contracts that were to be let three basic types of packages appropriate to small, medium and large value contracts were produced. Conditions of contract had to be amended to incorporate a number of special requirements, particularly to define Buro Happold's role as construction managers, and essential to this was the contractor's co-ordination agreement. This gave authority to direct the contractors' sequence of working and to apply cross-penalties in the event of damage or delay by another contractor. A further unusual feature was that each contractor was required to re-warrant any previously completed works, of a similar nature to that within their scope.

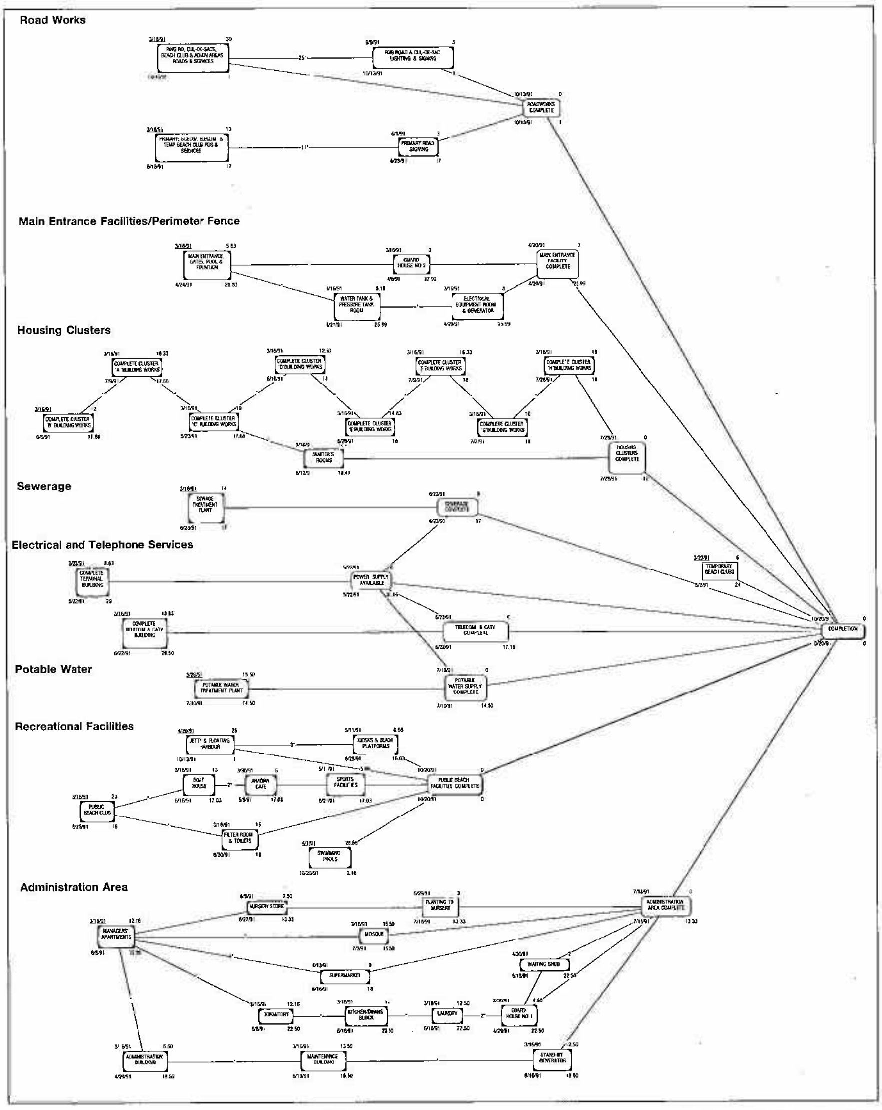


Fig 4.4 Construction sequence programme for infrastructure and buildings

During negotiations with the subcontractors it quickly became clear that satisfactory contractual arrangements would not be easily achieved. In these circumstances, and because SHARACO's tendering rules required a minimum of three tenders procured for each contract package, the contractual approach had to be amended accordingly. The completion programme was consequently affected by protracted negotiations.

Reletting of contracts

After lengthy negotiations the first major package for the M&E works was let to the contractor who had been the sub-subcontractor for the electrical works only under the original contract. Tenders for the second major package, the general building works, which comprised mainly of finishing trades, were received on 4 August 1990, just two days after the invasion of Kuwait by Iraq. At least one of the tenderers seriously considered withdrawing in the circumstances, but after some discussion submitted his tender. As the prevailing political conditions were not conducive to finalising contracts, the package was not awarded until 27 September 1990. This delay led to the first revision to the master programme to re-sequence the early

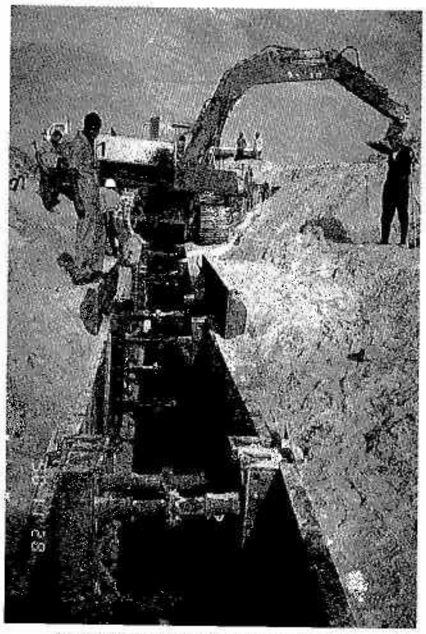


Fig 4.5 Ground work under way again on site

operations, followed by a second revision as the contractor took six weeks to mobilise, against his contractual commitment to do so within two weeks.

Despite difficulties in finding contractors willing to commit themselves in the prevailing uncertainty, contracts for deep sewerage, waterproofing, pre-engineered steel buildings, roadworks, aluminium works, packaged sewage and water treatment plants, landscaping and hardscaping, floating harbour, gates and barriers, jetty, beach platforms, fencing, vehicular barriers and external signage were subsequently awarded.

With so many contractors working simultaneously on a site already so out of sequence, one of Buro Happold's major roles was to implement the programmes devised for completion. This was achieved by means of regular and frequent meetings with the individual contractors, which towards the end of the contract were held twice weekly. In addition, weekly co-ordination committee meetings took place, attended by the senior representative of each contractor. This provided the formal forum for the discussion and resolution of access to the 'site' by each contractor, as defined by the programmes imposed on them.

Progress of works

Progress of the whole project was naturally

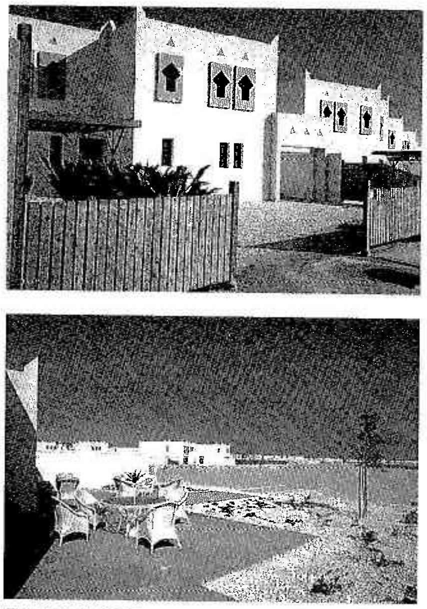


Fig 4.6 a, b Completed accommodation of Phase 1

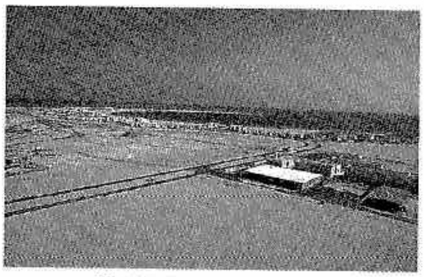


Fig 4.7 Phase 1, from microwave tower

affected by both the build-up to and the Gulf War itself, with contractors experiencing difficulties with labour and materials availability, particularly with imported items. In the first few weeks after the invasion a large number of Asian workers left the area. Another difficulty was the scarcity of locally produced materials due to the increased demand from the allied forces. The build-up to the war produced a boom in some sectors of the Eastern Province economy with heavy equipment commanding significantly higher charge-out rates than normally achieved. Consequently, a particularly difficult contract to finalise was the roads package, which had to be re-tendered after the subcontractor of MABCO agreed terms but later withdrew, as did the low bidder of the subsequent competitive retender, who found more lucrative work with the armed forces.

At the outbreak of war a sense of nervousness spread rapidly through the site which it was felt if left unchecked could lead to panic and evacuation. Given the relative remoteness of the site from the presumed target areas of Dhahran and Al Khobar, Buro Happold and SHARACO decided to relocate their accommodation to the site. Many contractors followed suit, and the site was consequently perceived as a safe place. Although some labour left, the majority stayed, and progress, although at a reduced level, was considerably better than on many other projects in the region, which closed down for the duration of the war.

While it was originally envisaged that Buro Happold would remain with the project to its overall substantial completion, the client extended the brief to oversee the final close-out of each of the packages. An unusual feature of this close-out was the reluctance of the client to impose the usual late completion penalties. In lieu he agreed with contractors that a reasonable extension of time be given for the effect of war and, where completion extended beyond the revised completion date, that additional works be carried out to a value, at bill rates, approximately equal to the penalties.

In reality there was no necessity at the end of the contract to carry out a final account reconciliation for any of the contractors since final accounts were effectively established and maintained throughout the contract period. This was achieved by agreement from all parties at the time, of all costs and time implications associated with any change orders.

Successful completion of Phase 1

In spite of all the potentially adverse effects which had been suffered during the duration of the project, substantial completion was achieved in November 1991 *(Fig 4.6 a, b)* undoubtedly assisted by SHARACO's commitment to complete the development as quickly as possible. Many delays traditionally suffered in this part of the world have been avoided with a responsible client presence resident on site.

The development's sales office opened in October 1991 and by the summer of 1992 most of the properties had been sold, with a high level of interest shown in the remainder. As a result of Phase 1's success, SHARACO are now in the preliminary stages of proceeding with a combination of Phases 2 and 3. In August 1992 Buro Happold commenced revision of the masterplan, which will comprise a total of 1,000 houses and a hotel, together with marina and lagoon.

Padraic Kelly and Graham Pontin

Quba Mosque, Medina

Project data

Client	Ministry of Hajj and Awqaf
Architect	Abdel-Wahed El Wakil
Contractor	Binladen Organisation
Shading structure	Dr Mohammed Rasch
Civil/Structural engineers	Buro Happold
Building services	William E Hannan & Associates
Quantity surveyors	Construction Management Partnership AG
Completion	1407H/1986
Site area	13,100m²
Net building area	6235m²

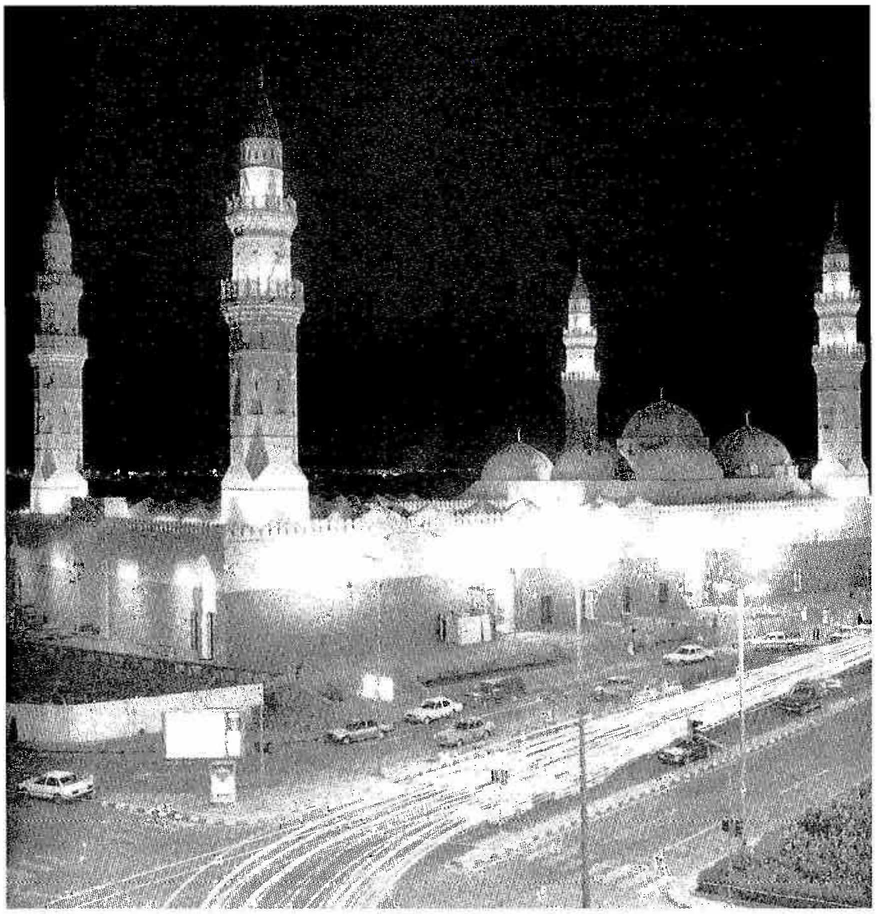


Fig 5.1 Exterior of completed Quba mosque

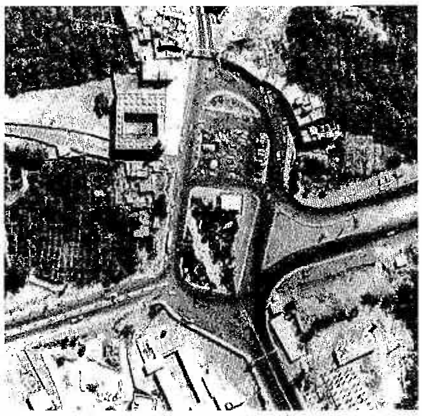


Fig 5.2 Aerial photograph of site

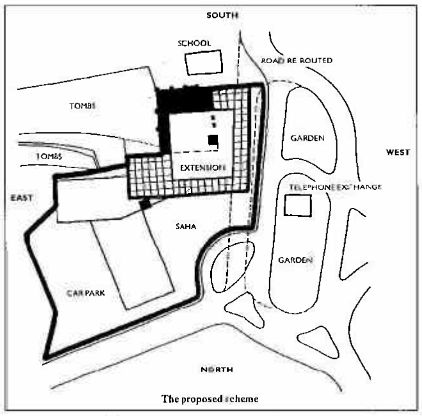


Fig 5.3 Plan of mosque site showing burial ground,school and Qibla wall

The new Quba Mosque, finished in 1986 and lying on the site of an existing mosque built some 150 years ago and restored in 1388H/1967, is designed to take up to 10,000 people for prayer *(Fig 5.1)*. Being some five times bigger than the existing mosque, it can be used by Muslims from all over the world for prayers during the Pilgrimage. With Mecca to the south, precisely determined by the orientation of the existing Qibla Wall, the mosque is located in the Al Munaura district of Medina, on the sacred and historic spot where the prophet Mohamed built the first mosque in the Islamic faith on his emigration to Medina. An existing burial ground is found to the east and a school to the south, permitting extension of the mosque only to the north, where the ground falls away by 3m *(Fig 5.3)*. For maximum site usage the Qibla wall was extended to the western edge of the site and the new grid then extended northwards.

The plan of the mosque, established after a survey of other mosques in the Medina region, follows the traditional form of a rectangular building with a central courtyard. This courtyard provides access to the prayer hall and is shaded by a lightweight retractable membrane, designed by Dr Mohamed Rasch for use during prayer and during extremely hot periods. The north end of the mosque is framed with a pair of minarets, the larger lying adjacent to the main entrance in the north east. The entrance porches do not lead directly into the mosque but maintain traditional movement patterns with circulation being offset from the main areas, and utilising a succession of spaces to lead into the courtyard contained by the prayer hall. The front prayer hall provides ample space beneath the six major 12m wide domes for daily prayer. For Friday prayers, the side and rear colonnades beneath the smaller 6.0m domes provide additional prayer space. The rear of the mosque together with an associated gallery over is set aside for women's prayer and has its own separate entrance. The prayer hall itself can

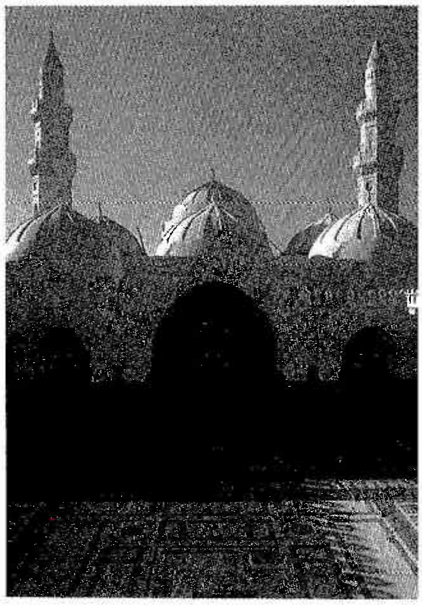


Fig 5.4 Interior courtyard of mosque

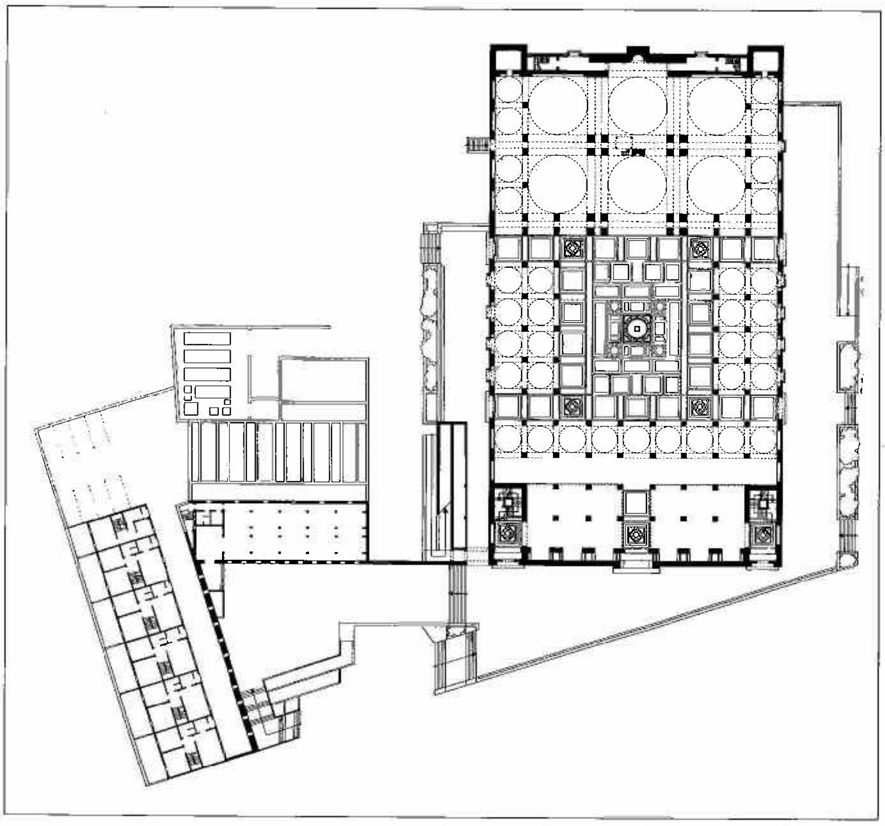


Fig 5.5 Plan of house, garden, shops and ablutions area

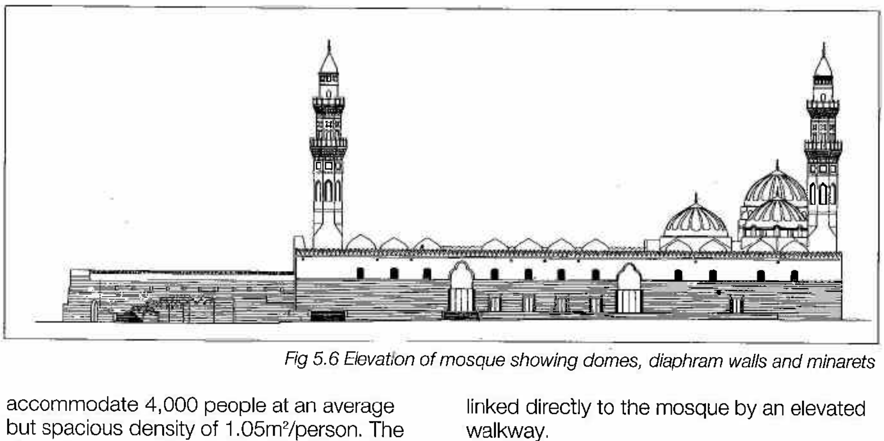


Fig 5.6 Elevation of mosque showing domes, diaphram walls and minarets

accommodate 4,000 people at an average but spacious density of 1.05m²/person. The Sahan terrace to the north of the mosque entrances will accommodate a further 1200 people at 2.1m²/person.

Parking and other facilities for the mosque are placed on the remaining north eastern part of the site adjacent to the Sahan. Six new houses with back gardens are included and are separated by a narrow lane from shops and ablutions areas *(Fig 5.5)*. Library and offices are located over the shops, linked directly to the mosque by an elevated walkway.

Environmental and services design

The physical environment within the mosque was carefully planned and controlled in order to produce an environment sympathetic to meditation. The concept of bringing the spaciousness of the sky into the volume of the mosque yet simultaneously providing shading in the courtyard was of major importance to the design. Indeed, the design of the air conditioning system relied on this concept coupled with the cool thermal mass of the brickwork construction of walls and domes, to achieve the selected criteria.

Cooled air is introduced at lower levels from plant located in the undercroft, via ductwork within wall cavities and grilles supplying the two separate main prayer and female prayer areas. Mechanical ventilation is also provided for ablutions and toilet areas. Within the mosque, light fittings are mostly suspended from roof domes with the distribution system located in the roof thereby keeping cable runs short and allowing easy maintenance.

Structure of mosque

It is not very often that an engineer is asked to help design a major building, completely of load bearing masonry, while maximising the use of masonry construction but without suggesting the construction forms, and simultaneously minimising the use of concrete, reinforcement and other technical devices. The six 12m diameter main domes, the many smaller 6m domes and the massive 1.0m thick surrounding diaphragm wall and much of the supporting pillars are built only from voided clay bricks, using reinforcement in bed joints to control cracking during construction. The minarets, some 40m and 35m high, are also of simple load bearing masonry although both are prestressed against excessive lateral loads by threaded high tensile rods by way of the central column and landings supporting the spiral staircase. Even the podium supporting the floor of the prayer hall and courtyard is designed such that maximum use can be made of hollow clay pot void formers. Slightly deeper than usual infilling reinforced concrete T-beams reduce both the volumes of concrete and the quantities of reinforced steel, and maximise the use of the locally produced clay void formers.

Loads from the piers supporting the roof vaults were transferred to the foundations by conventional lowly stressed reinforced concrete piers, themselves supported on a combination of pad foundations in the south and driven cast in situ piled foundations. A similar division of foundation method was provided for the massive enclosing 10m high brick diaphragm wall that encloses the mosque. Rock strata outcrop in the area of the existing mosque on the south of the site thus enabling direct pad foundations, but dip at a sharp angle of 25° approximately to the north, making normal bearing strip foundations too deep. In this case loads were shared by groups of driven cast in situ piles to provide settlement characteristics similar to the rock bearing pad and strip

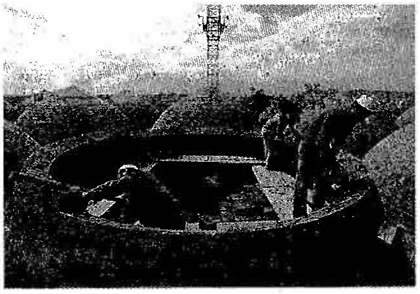


Fig 5.7 Typical small dome in construction

Fig 5.8 Typical construction without forms of larger dome

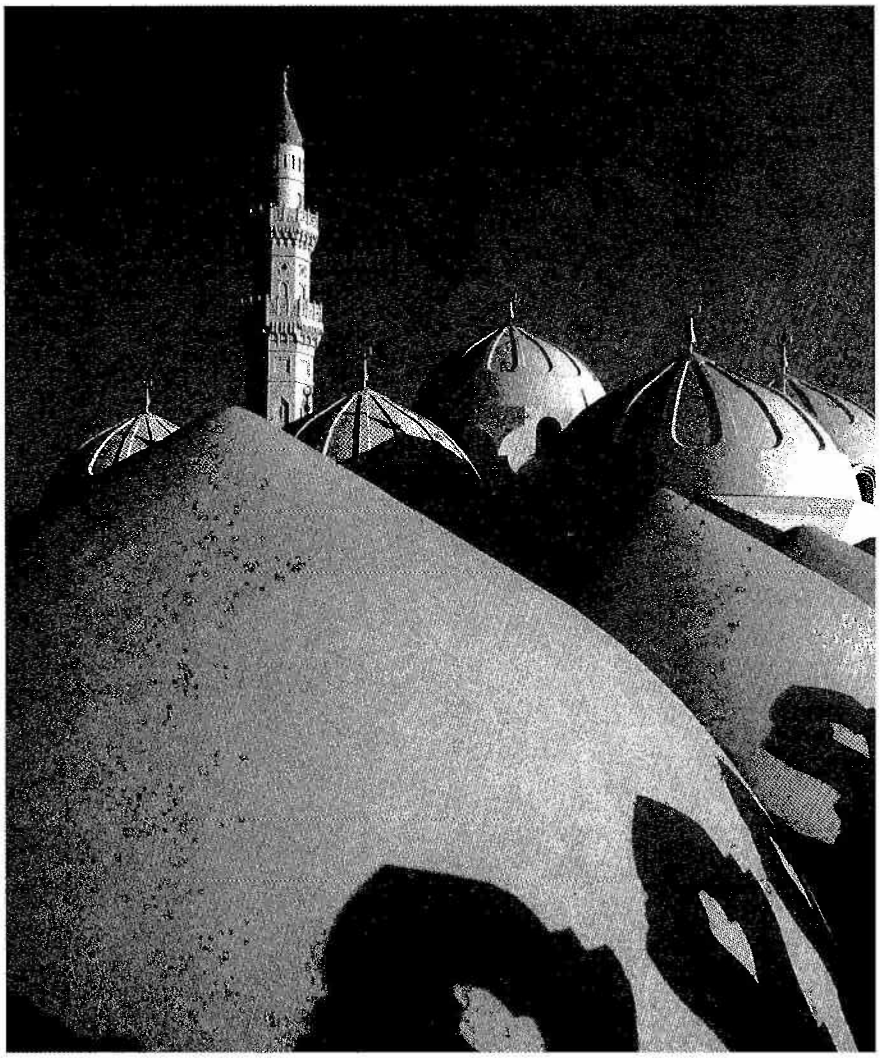


Fig 5.9 Roofline of finished mosque showing domes and minarets

foundations.

The structure to the six large 12m domes and the many smaller 6m domes is in loadbearing masonry built without forms *(Fig 5.7 & 5.8)*. The use of $19N/mm^2$ voided clay blocks 240x175x113 mm or 240x115x113 mm high at an average density of $15/kN/m^3$ reduces weight and by careful choice of workability, the short term cohesion of blocks when laid on the inclined wet mortar bed is enhanced. The mortar was normally specified as a mix of 1:1:6 cement lime sand with a strength of $2.5N/mm^2$ to give a design compression strength to brickwork BS 5628 of $5.64\ N/mm^2$. Thrust lines were calculated for the larger domes for individual segments of the dome. Under self weight these remained within the profile of the masonry itself so indicating that the domes are stable under their own weight. However, hoop tension cracks would develop in the lower part of the dome due to the presence of tensile membrane stresses along the lines of latitude. In order to reduce cracks to acceptable levels, additional reinforcement was provided in the bed joints of 2 - 6mm or 8mm bars, depending on location, each having 20mm minimum cover both to resist these hoop tension stresses and to improve stability during construction.

Notwithstanding the finish of white painted reflective plaster covering to the domes and roof, one of the principal concerns for the design of a building as large as this was the provision of satisfactory movement joints within the roof plan. These were necessary to prevent the build up of excessive thermal stresses resulting from variations between minimum night time temperature in winter and peak summer time surface temperature in the order of 70°C. A combination of movement joints and dowel bars was introduced to maintain overall stability within the design. Additionally the black marble cladding hung off the lower area of the perimeter wall, for which an even greater thermal range was expected, was detailed by placing movement joints on a regular 6m grid to allow unrestrained expansion of each individual marble panel.

Despite the huge volume of clay bricks and void formers laid using only conventional masonry techniques and without the aid of predefined geometry of support scaffolding, the basic construction was completed in around one year. There followed careful application of traditional decorative Islamic finishes to vast areas, all to the designs specified in considerable detail in drawings and models by the architect. Both elements of such a large scale construction would not have been so readily achieved without the architect's exceptional knowledge of both traditional masonry and Islamic features, and the disciplined application by the contractor of engineering design and methods. As a result it is to be sincerely hoped that the completed construction does fulfil the client's aspirations for a place appropriate for pilgrimage, prayer and meditation.

Michael Dickson and Richard Harris

Strengthening of a 26-storey apartment tower - The Sultan Tower, Cairo

Project data

Client	Mohamed Sultan
Structural engineers	Buro Happold (structural audit/site supervision)
Completion date	anticipated 1993

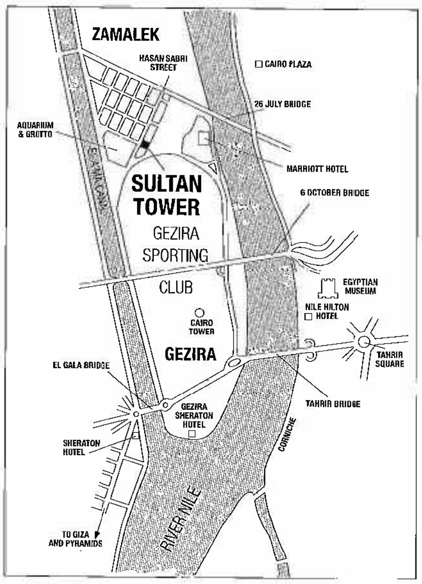


Fig 6.1 Location plan of Sultan Tower in Zamalek

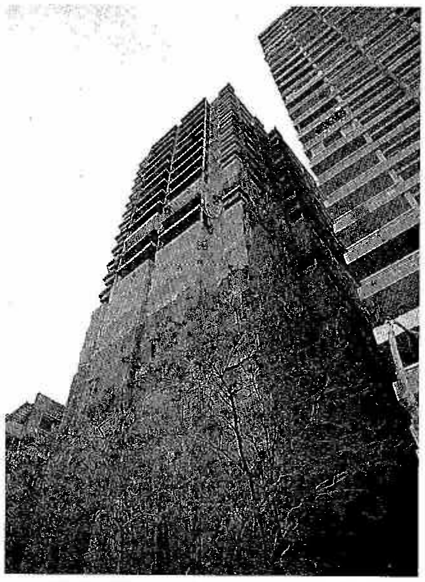


Fig 6.2 The 26 storey tower wrapped with hessian at lower levels to contain gunite spray

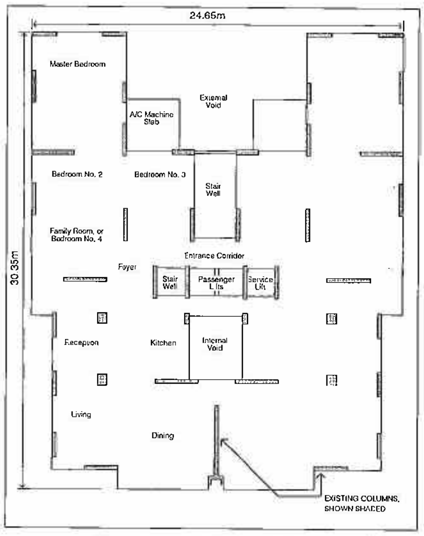


Fig 6.3 Floor layout of building as initially constructed

During the late 1970s and early 80s a number of failures of completed high rise apartment buildings occurred in Cairo, with consequent loss of life. At this time, the Sultan Tower, a 26-storey apartment building in Hassan Sabry Street, on a site overlooking the park in Zamalek *(Fig 6.1)*, was under construction. However, only the structural frame of the building had been constructed and as a precautionary measure, the owner put in hand a structural appraisal of the development for the purpose of verifying strength and stability.

A first appraisal

The building, of concrete construction, has hollow pot flat slab floors. Ribs span on to beam strips which in turn span between columns. The columns are generally long in one direction and narrow in the other, so that they can be 'lost' within the apartment interior and exterior walls *(Fig 6.3)*. Consultants employed by the owner for the structural check found many of the columns to be under-strength, especially at lower floor levels. Whilst there was significant potential column stiffness throughout the building, this was not matched by any substantial floor beam system which could have acted with the columns to provide wind frame resistance. The building therefore required strengthening of columns, and the introduction of wind shear resistance together with some floor strengthening. Schemes to solve these problems were prepared by the consultants and were given to the French contractor, Freyssinet, for pricing. The contractor, however, raised doubts on the design of strengthening and of the wind frame, and Buro Happold were approached by the owner for a second opinion in 1985.

Reassessment of structural appraisal

The consultant's initial approach had been very cautious in relation to column and floor strengthening. Few of the columns or slabs satisfied the CP 110 requirements for minimum main reinforcement, or minimum links or stirrups, so leading the consultant to the view that virtually all columns and slabs had to be strengthened, regardless of their strength. However, the Egyptian Arab Republic Code of Practice for Concrete Structures and the former British code CP 114, on which the Egyptian code was largely based, did not have such stringent requirements for minimum reinforcement. Some of the beam strips within the floor slabs did not satisfy CP 110 requirements for minimum main reinforcement, or minimum links or stirrups but fell within requirements of both CP114 and the Egyptian code. A few spans did not satisfy the calculation requirements of any of the codes, and yet performed well under load test.

As a result, Buro Happold recommended that CP 114 or the Egyptian Code, which were both valid at the time of construction of the concrete structure, should be used as a basis of the design check. Accordingly, Buro Happold further recommended that strengthening be limited to those elements which were found to be under-strength, either by calculation or by test. Honeycombing and any other defects in the existing construction would of course need to be repaired, but strengthening would not be used if not found to be necessary by the above criteria.

A new solution

The consultant's proposed method of provision of wind shear resistance was by the introduction of column and beam frames *(Fig 6.4)* - one in the central service well, and the other in the external well between the air conditioning equipment support slabs. Each of these two frames consisted of four large columns linked by large beams at each floor level, calculated to resist wind forces by bending action of the frames. As these frames could only work after excessive distortion of the building, Buro Happold recommended that a stiffer wall system be introduced instead *(Fig 6.5)*, using as much length of wall as could reasonably be introduced in the internal and external wells. This view was also shared by Freyssinet, and the consultant agreed to amend the design. Whilst the designs finally adopted for the wind shear towers *(Fig 6.6)* were smaller in plan than Buro Happold had proposed, they were of larger wall section, therefore performing their function without allowing undue deflection of the building or excessive floor to floor drift. With the introduction of the new wind towers in the Sultan Tower the generally accepted maximum sway movement of one five hundredth of a building's height at the top of the building would not be exceeded

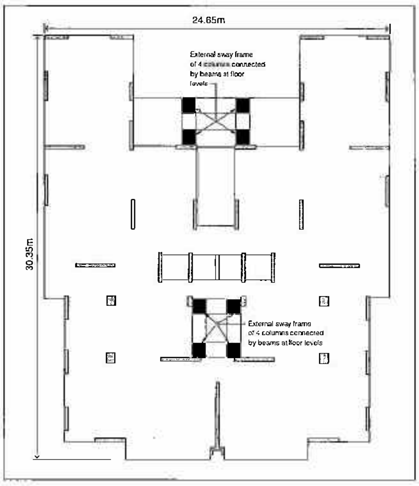


Fig 6.4 Consultant's initial proposal for sway frames. The flexibility of the frame system over the 80m building height would have led to excessive deflection

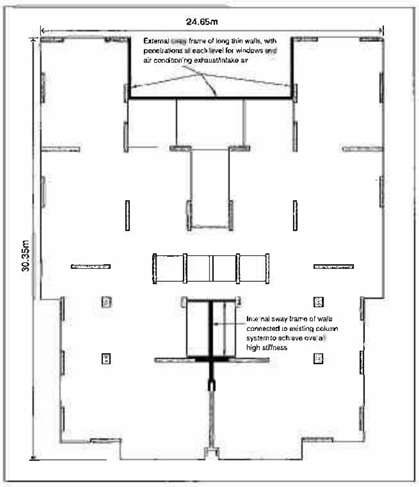


Fig 6.5 Buro Happold's response to the consultant's initial sway frame proposal. The introduction of walls , connected where possible to the existing column system, would achieve a high stiffness/strength ratio for the sway frames

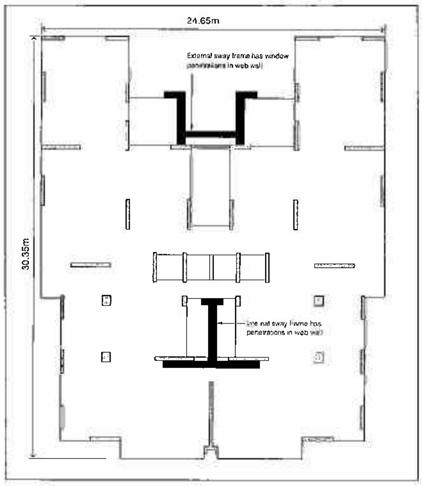


Fig 6.6 The consultant's final sway frame design. The frames occupied a small plan area, and therefore needed thick wall construction at lower levels to achieve the required stiffness

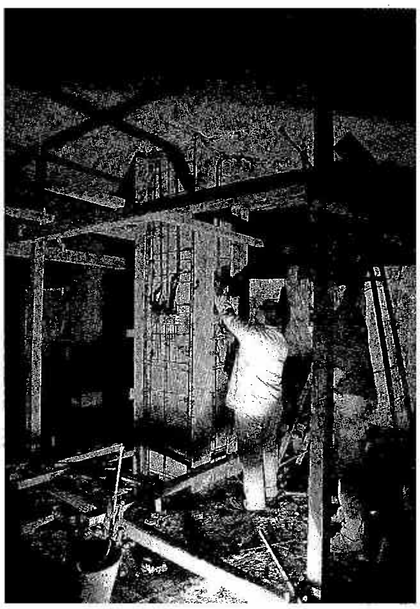


Fig 6.7 a Column being prepared for guniting

Fig 6.7 b Guniting a column

Fig 6.8 Gunite repairs to slab sofit

Supervision on site

Buro Happold were retained by the owner to check and certify all strengthening design, and then to supervise on site the strengthening and wind shear tower construction. The owner opted to act as contractor, because he felt that only by having direct control of each work task would he be able to control quality over the wide range of work, much of which was complex or specialised. He considered that by employing Buro Happold's supervision together with his own locally-recruited engineers to carry out management and supervision, he would complete the works economically using local skilled and unskilled labour. His view proved to be correct and work proceeded well in the gunite strengthening of the columns *(Fig 6.7 a, b)*, repairs of defective workmanship, and construction of new pile caps and the internal wind tower. The repairs, strengthening and wind tower construction are of good quality and stand in sharp contrast to the quality of the original construction. Much of this work is now complete and the structure has taken on a robust appearance.

However, at the time of writing, the building cannot be completed. It remains on the files of the Cairo Municipality as a building without final planning permission. There is no longer any structural impediment and hopefully this administrative delay will soon be resolved.

After the Cairo earthquake in 1992, the building was examined for cracks and other defects. At that time only the internal wind frame had been completed. No signs whatsoever of cracking or other distress were found, in contrast to such damage to adjacent buildings.

Terry Ealey

Damage assessment in Kuwait

Project data	
Client	Kuwait Real Estate Company/Kuwait Ministry of Defence
Engineer	Buro Happold
Principal contractors	Al Baher & Bardawil Yousef Al Ghanim & Sons Al Moaed Al Usaimi Greenline Bader al Mulla
Project value	£4.5m/not to be divulged

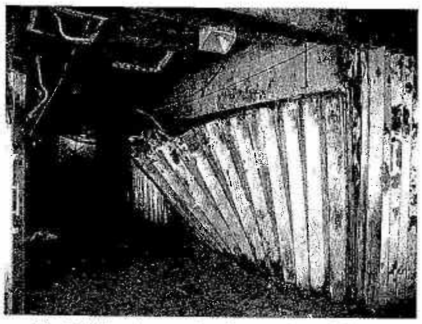


Fig 7.1 Fire damage to shops at Souk Al Kuwait

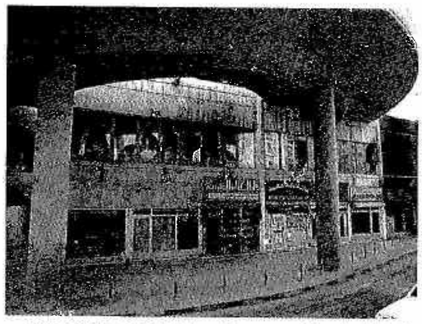


Fig 7.2 Fire and looting damage at Souk Al Kabir

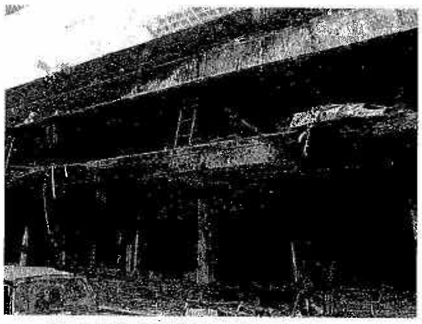


Fig 7.3 Souk Al Kabir - fire damage to exterior

Fig 7.4 Fire damage inside Souk Al Kabir

Post-liberation television, newspaper and technical journal coverage of war damage in Kuwait led the world's consulting and construction industry to expect a reconstruction bonanza which might save those either quick or lucky enough to get in on the act from the ravages of a deepening, worldwide recession. However, this was not to be the case. What first struck the post-liberation visitor to Kuwait, pre-conditioned by the media to expect perhaps even a flattened Kuwait City, was how much the city looked the same as before. As these first impressions of a city hardly touched by ordnance damage began to fade, so came the realisation that there was indeed considerable damage, not so much requiring reconstruction, but of a depressing nature. A rampage of wanton looting, vandalism and destruction had left Kuwait resembling a ghost city.

Nearly all homes, offices and shops had been looted, and hotels and a number of other buildings had been deliberately set ablaze. Cars were in evidence everywhere, not being driven, but piled on the sides of roads, smashed and with wheels missing. Beaches were mined, substations were wrecked, there was barbed wire everywhere, and the sky was densely overcast with smoke from more than 600 oil fires. Restoration of electricity supply, telecommunications, water supply and sewage disposal was of prime importance, and this was achieved in an impressively short space of time, as was the capping of the oil fires. Clearance of literally millions of mines and hundreds of thousands of tonnes of ordnance material has proceeded apace, with most beaches cleared by mid 1992.

In the building sector, construction activity has been very much related to demand for space. In order to repair buildings, tender documents must be produced, but before this can happen a damage assessment has to be made which identifies and records the damage, assesses the options and costs for repair and replacement, and establishes a feasible programme and contract method for the construction works. This damage assessment should also be capable of being used as a supporting document in claims for compensation through the United Nations Commission for Compensation. For many months no clear guidelines were issued on the required format and content of a damage assessment report, and consequently government and private sector clients were reluctant to proceed until they needed the floor space, and therefore had to carry out the repairs.

The Kuwait Real Estate Company (KREC), Kuwait's leading real estate company, suffered particularly extensive damage to a number of its developments, and early after the liberation Buro Happold were asked to make a preliminary assessment of damage and structural safety at several of its buildings.

Damage to KREC developments

The Souk Al Kabir and Souk Al Kuwait, each exceeding 50,000m² in floor area, were built between 1973 and 1976. Each comprises two floors of basement parking, shopping on ground and mezzanine floors, multi-storey car parking over the shop levels, and offices at top levels. The Souk Al Kuwait had suffered vandalism and fire damage in one area at ground level *(Fig 7.1)*, which although resulting in extensive damage to building services and finishes had not so seriously affected the structure. The damage to the Souk Al Kabir was far more extensive. Most of the shops on both ground and mezzanine levels had been looted with doors and

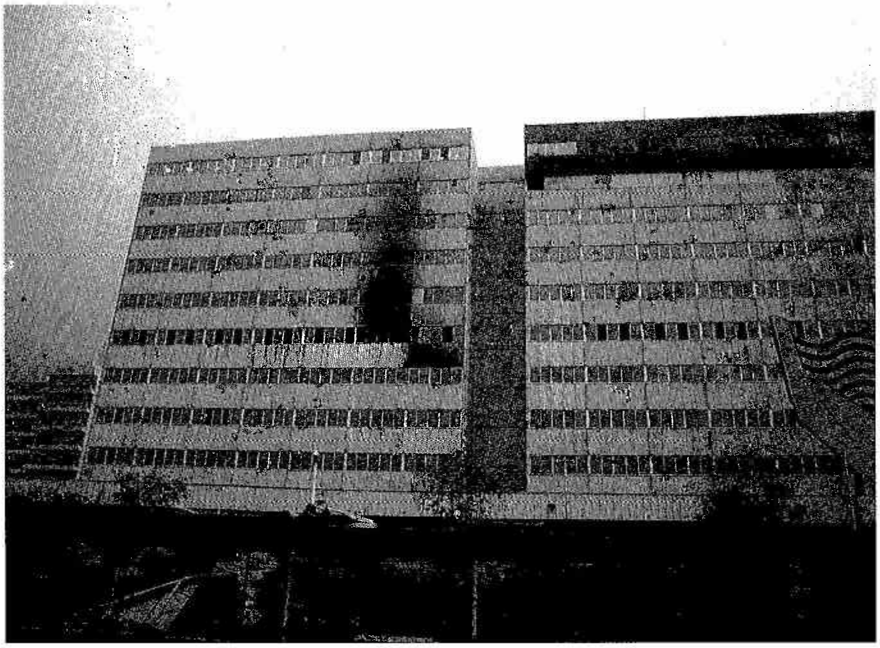


Fig 7.5 Damage by fire at Ministry of Electricity and Water (MEW) Headquarters

Fig 7.9 Destruction of walls and columns by tracked vehicle - MOD complex

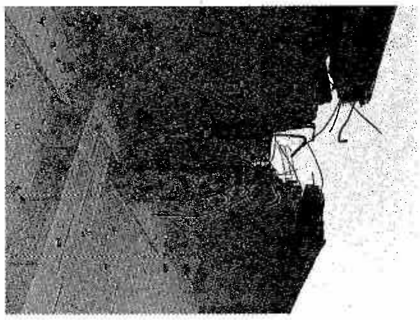


Fig 7.6 Shell damage to balcony of Al Durrar apartment complex

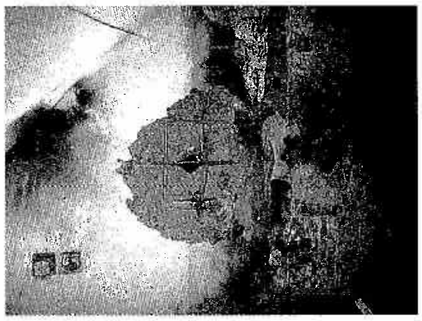


Fig 7.7 Shell damage to concrete wall of MEW building

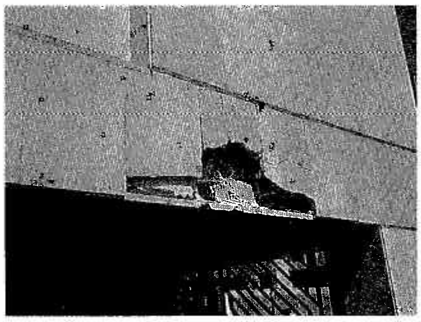


Fig 7.8 Shrapnel damage to marble facade of studio apartment complex at Al Fintas

windows smashed and many had been set ablaze, resulting in widespread fire and smoke damage *(Figs 7.2 & 7.3)* Eighty-seven separate fires were identified during the appraisal, completely destroying building services and finishes in most areas. At the areas of intense fire *(Fig 7.4)*, severe damage had occurred to all elements of the building structure, with floor slabs showing signs of partial failure in several locations.

The eleven storey Ministry of Electricity and Water (MEW) headquarters office building had suffered damage from shelling and small arms fire during the early days of the Iraqi invasion *(Fig 7.5)*. Subsequent vandalism, and damage from some nineteen fires started by the occupying forces in the last days of the occupation, had prevented the Ministry from using nearly half the building. A speedy refurbishment was vital to ensure continuation of the lease.

Located close to the MEW building, the Al Durrar complex comprises three nine storey apartment blocks. Damage had been caused mainly by vandalism, fire, and a number of shells which had hit the buildings *(Fig 7.6)*. Building facades were also affected by shrapnel and small arms fire.

The residential Fintas Studios complex of 108 studio apartments had been extensively

Fig 7.10 Destruction by tracked vehicle in MOD complex

Fig 7.12 Vandalism to laundry equipment - MOD complex

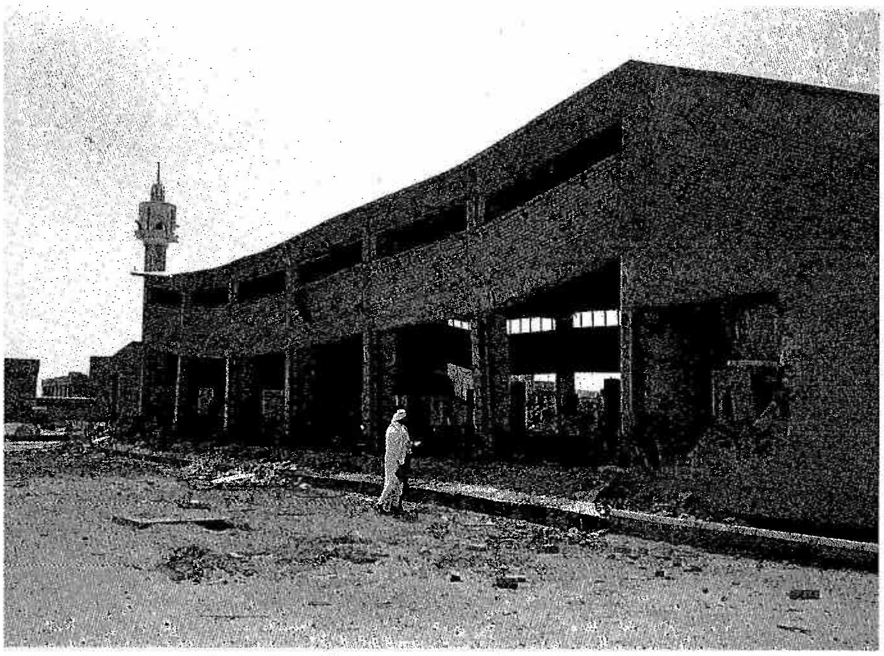


Fig 7.11 Explosive damage at base of columns in maintenance building of MOD complex

vandalised and the external marble cladding had suffered extensive shrapnel damage *(Fig 7.8)*.

At about the same time, Buro Happold was also appointed in association with local consultant, OHA, by the Kuwait Ministry of Defence to carry out damage assessment on a large military project which had been under construction at the time of the invasion. The site occupied an area of approximately 40 hectares containing over 80 structures. These included ammunition stores, warehouses, dormitories and workshops, constructed in concrete frame with a cladding of sand lime bricks. The project had been nearing completion at the time of the invasion and was used by Iraqi troops during the occupation. The principal damage to the structures had been caused by tracked vehicles driven into building facades *(Figs 7.9 & 7.10)*, although in some instances explosives had been used to effect partial or complete collapse *(Fig 7.11)*. Extensive looting of materials and equipment had taken place and buildings had been badly vandalised *(Fig 7.12)*.

A preliminary assessment of damage to these KREC and MOD properties was made, principally to ascertain the safety of the buildings, and to identify any immediate temporary propping or other safety measures which might be required. The process of full damage assessment then followed.

Assessment of damage

Damage assessments were intended for use as a basis for any claim through the United Nations and for tendering repair and refurbishment work. Careful examination and full and detailed recording of the damage was required, together with an estimate of the repair work required to restore the building or element to its former condition. This required the handling of a large volume of data, and a system was devised to input information recorded by the damage assessor to a database and information management computer system.

Spreadsheets were prepared for each of the major components of the building - external works, electrical installation, building finishes, fire fighting equipment, lifts, mechanical installation (air conditioning, plumbing and internal drainage), structures and

Damage Class	Description of Damage	Description of Repair
Beams		
Class 1	Soot or smoke deposit; minor spalling only and practically no exposed reinforcement	Clean, and make minor repairs with resin repair mortar.
Class 2	Substantial spalling along edges only, revealing main reinforcement (outer surfaces of corner bars only) - microcracking of surface - concrete cover to soffit may have hollow ring; concrete colour black/pink.	Clean; remove all loose and hollow material; break back behind reinforcement in places where de-bonded; gunite or resin mortar back to original profiles.
Class 3	Substantial spalling over soffit/sides, revealing reinforcement generally intact - about 50% perimeter of exposed main bars still in contact with concrete; limited number of main bars buckled; concrete colour buff; no severe deflection.	Clean; remove all loose and hollow material; break back behind reinforcement; add additional reinforcement and mesh; gunite, generally to larger than original profiles.
Class 4	Severe damage, including extensive spalling to soffits/sides revealing practically all of the main bars; severe deflection and/or fractures; several main reinforcing bars may be buckled; concrete colour buff/grey.	Replace beam, either directly or indirectly.

Fig 7.13 Example classification for fire damage to structure

Damage Class	Description of Damage	Description of Repair
False Ceilings		
Class 1	Soot and combustion product deposition, which can be cleaned.	Clean, with suitable cleaner (non-alkaline for aluminium surfaces)
Class 2	Local damage, and/or soot and combustion product deposition, which can only be partly cleaned.	Clean as (1) above, taking down and replace damaged or otherwise non-restorable panels as necessary.
Class 3	Local damage, and/or fire, soot and heat damage to ceiling or services or void above, which requires removal of the ceiling.	Remove ceiling, check supports and reinstate using some existing panels as possible (cleaning as necessary).
Class 4	Total damage.	Replace ceiling.

Fig 7.14 Example classification for fire damage to finishes

Damage Class	Description of Damage	Description of Repair
Ductwork		
Class 1	Internally smoke damaged, or dust build-up.	Vacuum/brush/blow out loose particles; specialist cleaning of remaining soot particles with alkaline based cleaner; possible requirement for ozone deodorisation.
Class 2	Smoke and heat damaged; possible heat deteoration of joints; heat baking-on of combustion products; heat and/or smoke effect on insulation.	Clean as (1) above; renew insulation, check joints and hangers,renew as necessary, and pressure test; deodorise and encapsulate interior of duct with polymer material.
Class 3	Not used.	Not used.
Class 4	Severe heat and/or impact or other damage.	Replace ductwork and insulation.

Fig 7.15 Example classification for fire damage to mechanical a/c installation

Damage Class	Description of Damage	Description of Repair
Light Fittings		
Class 1	Light smoke damage	Clean, using appropriate cleaners and possibly employing specialist cleaning techniques on diffusers.
Class 2	Smoke damage/light heat damage	Clean, using appropriate cleaners, replace any louvre diffuser, test and overhaul, relamp and set to work.
Class 3	Not used.	Not used.
Class 4	Severe heat and/or impact or other damage.	Replace light fitting.

Fig 7.16 Example classification for fire damage to electrical installation

telecommunications. These were produced in a multiple choice format in order to standardise descriptions and assist in the transfer of data to the information management system. A record of location, item, type, extent and suitable repair for each instance of damage was then made and a typical completed spreadsheet therefore carried a row of circled descriptions, against which the assessor had placed an estimated quantity. A completed spreadsheet line might therefore read: Zone B/Room 302/Walls/blockwork/complete damage/complete replacement/50m². The input of data to the database and information management system permits ready access for production of budget costs but may also be used to collate information under various element or area headings.

Classification of damage and repair

A damage classification system was used in which the observed damage for any element was categorised into one of four classes, ranging from Class 1 (minor damage such as smoke staining) to Class 4 (the most severe - destruction). Classes 2 and 3 described intermediate cases, but were not necessarily used in all instances. For each element and damage class there was an associated class of repair. In addition a colour coding system for each class of damage was used on floor plans to give an immediate visual impression in the report of the severity of damage. The damage tabulation also proved useful in the production of tenders for repair and refurbishment works, as the descriptions were used as the basis on which tenderers priced the works. Some summary example classifications for damage and repair for structure, mechanical and electrical services and finishes are shown in *Figs 7.13 to 7.16*.

Assessment and repair of fire damage to structures

Structural concrete and reinforcing steel are essentially non-combustible materials, but can, however, undergo changes in physical and chemical properties when exposed to high temperatures. In assessing structural concrete after exposure to fire, consideration must be given to the duration and intensity of the fire, the temperature development in structural members, the effect of the estimated temperatures on the engineering properties of the concrete and steel, the feasibility of repairs and the effects of chemical attack by aggressive gases.

Research has shown that concrete is not substantially affected at temperatures of less than 300°C. This is useful in assessment, as discolouration of concrete occurs at temperatures above this level. A visual examination of colour change through the concrete gives an indication of the loss of strength and shows the depth to which the concrete is affected. Steel reinforcement is also affected by heat. However, if it can be deduced from the colour of concrete that the temperature did not reach 300°C at the depth of cover, then the strength of reinforcing steels other than cold worked or special steels will be little affected.

The effect of carbonation of concrete is to neutralise its alkalinity and reduce corrosion protection to the reinforcement. During a fire the elevated temperatures and large quantities of combustion gases together create an environment for rapid carbonation. Depth of carbonation can be tested by treating the concrete with an indicator to check for alkalinity. The long term risk to the structure depends upon environmental conditions, including air temperature and humidity and on the porosity, carbonation, type of cement and aggregates of the concrete.

Columns were checked by Schmidt hammer, by coring, and for hollowness by use of a hammer. The underside of all slabs was also checked for hollowness and was examined visually for colour, spalling and cracking *(Fig 7.17)*. Schmidt hammer tests were carried out on sample areas of slabs and beams, while depth of carbonation was determined by phenolphthalein testing.

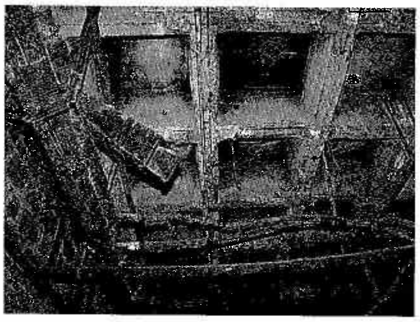


Fig 7.17 Spalling at underside of waffle slabs caused by fire damage

Fig 7.18 Resin injection of cracks in fire damaged concrete

Many fires were of such intensity to cause major structural damage. Fortunately the columns in all locations were of sufficient size that damage was limited to spalling, which in some places was nevertheless extensive. Particular care is needed with columns to ensure that spalling has not made links ineffective as restraints, allowing reinforcement to buckle outwards, or indeed that repair methods do not introduce such instability. Damage to slabs varied according to slab type. Ribbed slabs suffered from various degrees of spalling, and in some cases rupture, depending upon the severity of fire exposure. In some locations flat slabs had deflected as the building expanded in the fire, and cracks had formed and not closed.

Methods of repair to each different damage

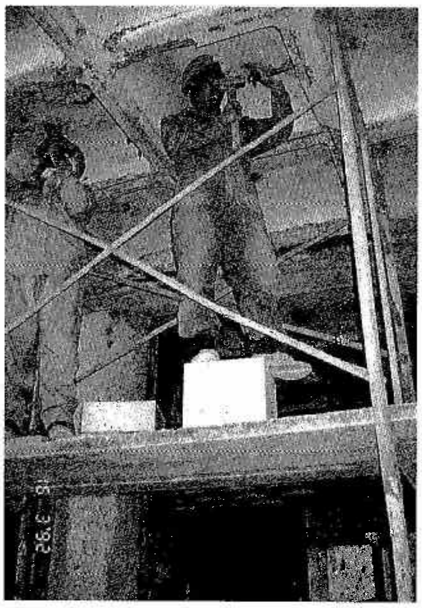


Fig 7.19 Removal of loose concrete from fire damaged waffle slab in preparation for gunite repairs

class included: Class 1 - cleaning with high pressure steam and low viscosity epoxy resin grouting of cracks *(Fig 7.18)*; Class 2 - removal of spalling and gunite back to original profiles *(Fig 7.19)*; Class 3 - removal of spalling, addition of new reinforcement and gunite to cover and bond new reinforcement *(Fig 7.20)*; and Class 4 - breaking out and replacement. Classes 1, 2 and 4 structural repairs were most commonly used, as Class 3 proved generally to offer insufficient cost saving over Class 4 on the badly damaged waffle slabs.

Assessment and repair of fire damage to mechanical services

Components of mechanical services systems are mainly metallic and are not flammable. However, joints and valves, glands and sealants are seriously affected by fire and may need replacement after being subjected to temperatures as low as 70°C. In areas of fires, ductwork and pipework was damaged beyond repair by the intense heat. Damage extended beyond the area of the fire by the spread of smoke through the building, causing soot to be deposited some distance from the fires, inside ducts and air handling plant.

In assessing damage, certain criteria including accessibility, compatibility and availability of replacement items were considered. This led to the conclusion that major repairs (Class 3 damage) were rarely

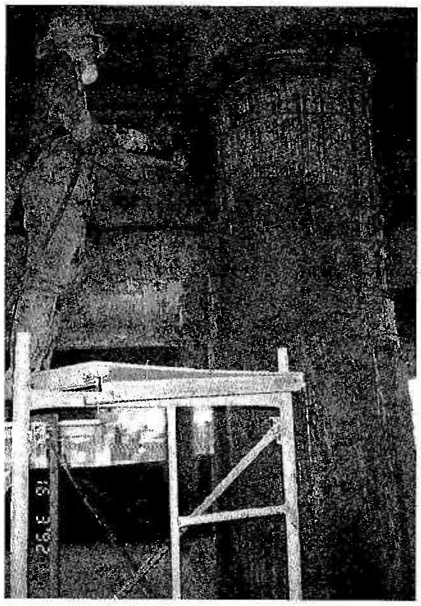


Fig 7.20 Gunite repair to column after removal of loose material and wrapping with additional mesh reinforcement

economically viable. Classes 1, 2 and 4 repairs were most commonly employed. Cleaning and deodorisation were carried out extensively. Soot deposits within the ductwork were firstly removed with brushes and vacuum cleaners. This was followed by ozone deodorisation, and the ducts were then sealed with a polymer film introduced as a mist into the ductwork system. Pipework and ductwork insulation was extensively replaced because of smoke contamination and possible long term odour problems.

Repair of fire damage to electrical services

Electrical services were badly affected by fires, as wires, cables, plastic conduits, socket outlets and light fittings all use plastic in their manufacture. Where cables passed through fire-affected areas, the whole cable lengths had generally to be replaced back to the distribution board. Large areas of buildings consequently had to be completely rewired.

All lifts, including those passing through severely fire damaged areas required only minimal repairs to be made operational. The lifts were put into service very quickly but were temporarily set not to stop at those floors where doors had been exposed to high temperatures and had to be replaced. Stainless steel lift doors suffered from the corrosive effects of gases generated by


Fig 7.21 Destruction of walls and structure of substation, and of switchgear

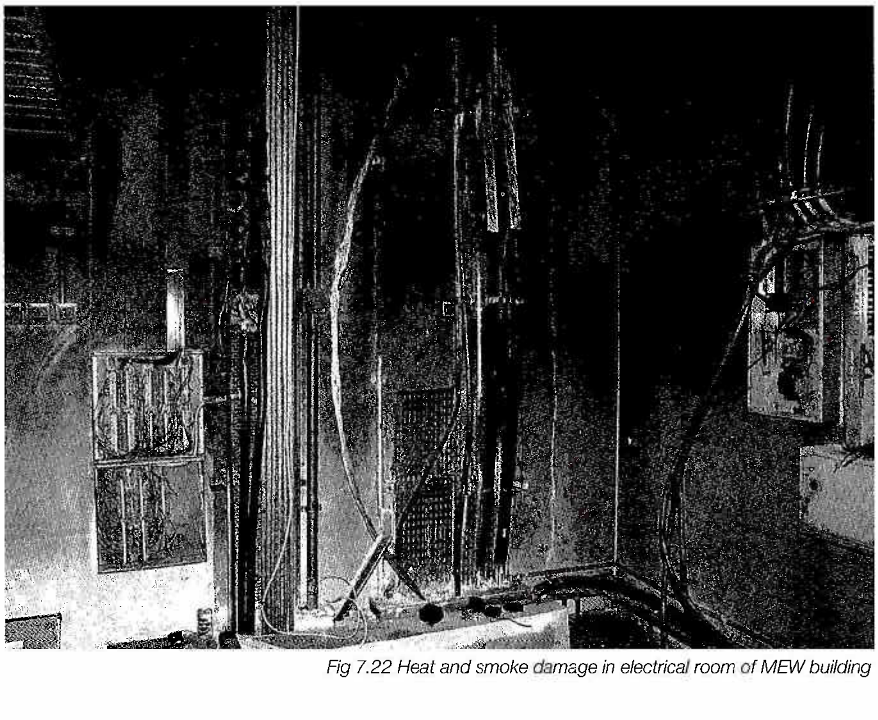


Fig 7.22 Heat and smoke damage in electrical room of MEW building

burning plastics.

Repair of fire damage to finishes

Finishes in the buildings included blockwork, plaster, plasterboard, partitions, floor finishes (screed, ceramic tile, terrazzo, marble), wall cladding, false ceilings, windows and doors. Effects were generally local to the fire but smoke spread necessitated extensive cleaning. Floors were also damaged during the clearing-out operation.

Steam cleaning was carried out at high temperatures and pressures and with various chemical additives dependent upon the type of stain to be removed. The only finishes impossible to clean satisfactorily were those which had been degraded by heat. Walls and facias performed very well; in most cases they had provided excellent fire separation and smoke containment. In several cases walls had to be demolished but in less intense fire areas replastering was sufficient.

Survey of war damage

Both photographic and video surveys were useful in recording the damage to buildings. Photographs were of particular use to include in the damage assessment report. Video surveys with contemporaneous sound description provided a valuable back-up record, and were particularly effective in the shopping areas where photographs could not always so graphically indicate locations.

Method of contract for repair and refurbishment

Following damage assessment of the buildings, documents were prepared for tendering for repair and refurbishment works. In most cases repair works were of a piecemeal or specialist nature and enabling works sometimes had to be carried out before the scope of repairs or replacement could be fully defined. For this reason repairs at most buildings have been carried out by a construction management approach, with Buro Happold managing a number of contracts to a master project programme.

Terry Ealey, John Froud and Richard Harris

Pearls of Kuwait: environmental assessment as part of the design process

Project data

Client	Pearls of Kuwait Company
Architects	The Jerde Partnership, USA Philip Cox, Richardson Taylor and Partners, Australia
Engineers, Project and Environmental Assessment managers	Buro Happold
Hydraulics consultant	Professor Patrick Holmes, Imperial College of Science and Technology

Fig 8.1 a The debris strewn beach of Shuwaikh Bay

Fig 8.1 b Aerial photo of existing coastal development

Even before millions of barrels of crude oil were spilled into the Gulf waters by Iraqi forces during their 1990-91 invasion, the standard of living for forms of marine life was deteriorating in the coastal waters off Kuwait. Several factors have led to this decline. Oil has been a major pollutant of the coastal zones of Kuwait for many years, derived directly from oil refinery and petrochemical industry discharges, illegal emptying of ballast waters, leakage from oil-exporting terminals and pipes, and accidental releases from offshore drilling *(Ref 8.1)*. In many places, particularly in Kuwait Bay, high levels of inorganic waste including sulphur and nitrogen compounds, heavy metals, phosphates, detergents, hydrocarbons and phenols are present resulting from industrial discharge *(Fig 8.1 a)*. Furthermore, domestic sewage overflow, released into the bay via stormwater outfalls, has given rise to not only a high level of faecal coliform bacteria but also localised accumulations of pathogens.

For the average Kuwaiti, life on the coast has been changing too. The sea has traditionally been an important part of daily life, water being brought by dhow to Kuwait in former times to supplement the limited well water supplies. The sea was also a source of pearls and food, with fishing for Gulf fish and shrimps traditionally a staple industry of Kuwait. Over the last forty years the country's population has multiplied tenfold, resulting in development both along the coast and inland. The Kuwaitis' desire to live

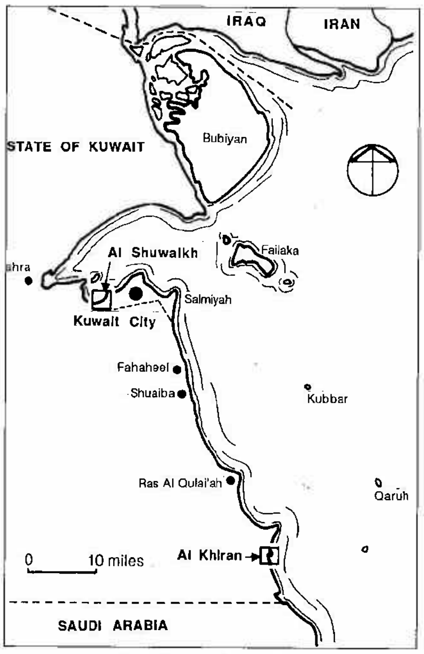


Fig 8.2 Location of development sites

beside the sea has remained however, resulting in extensive, unplanned development of weekend chalets along much of the coastline from Kuwait City to the Saudi Arabian border *(Fig 8.1 b)*.

A new coastal city

As good quality coastal land has become more scarce, there has been increasing pressure to develop those areas of coastline which because of pollution and poor ground conditions have previously been regarded as unsuitable. Out of this was born the concept of creating new cities, built either on the coast around tidal creeks and lagoons or in shallow waters just off-shore. Buro Happold were asked by the Kuwait Real Estate Company (KREC) to undertake a feasibility study during 1987 to identify a number of potential development sites along the coast of Kuwait. Of these, two were selected for further study; one at Al Shuwaikh along the south side of Kuwait Bay and the other at Al Khiran, further south down the coast from Kuwait City *(Fig 8.2)*.

A decision was made to hold an international design competition for the project, so permitting the development of ideas for the site by leading planning consultants in the field of waterside development. Before this could take place, however, it was necessary to undertake preliminary surveys of both sites collecting background information and establishing geotechnical and hydrodynamic

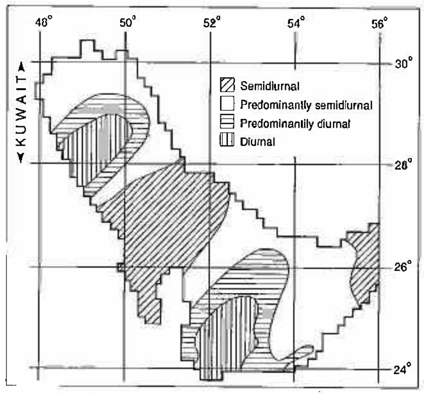


Fig 8.3 Classification of tides of the Arabian Gulf

characteristics, water and substrate quality. A number of important aspects emerged from these studies which had to be taken into account during the development of design ideas.

Preliminary survey results

Tides within the Arabian Gulf are complex, with generally two high and two low waters per day, each often differing in height *(Fig 8.3)*. Tidal range reduces along the Kuwait coastline from north to south - in Kuwait Bay the range can be as great as 4.2m during spring tides and as low as 0.5m during neaps, while at Al Khiran, the mean tidal range is around 1.6m with a maximum range of 2.4m at spring tide. Tidal currents flow parallel to the coast and rarely exceed 0.5m/s. Littoral drift is northbound from Al Khiran to Kuwait Bay during winter due to seasonal stormy south-easterly winds. In summer, under more settled weather conditions, this generally reverses to southbound along the Gulf coast and eastbound in Kuwait Bay. The Gulf coastline of Kuwait is marked by a succession of bays with exposure to waves varying according to aspect. Waves along the Gulf Coast rarely exceed a height of 4m, while in the shelter of Shuwaikh Bay, a height of 0.5m is rarely experienced.

All tidal and wave data must be considered while developing design configurations for reclaimed land. In this case it was of critical importance to ensure that water movement within the water bodies created around and amongst the islands of both sites would be sufficient to avoid undue sedimentation and stagnation. At Al Shuwaikh, maximum advantage would need to be taken of tidal flow and currents to ensure that the artificial creeks would be adequately flushed through thereby avoiding stagnation, and that beaches along the islands' shores would be cleansed by waves and tides. On the other

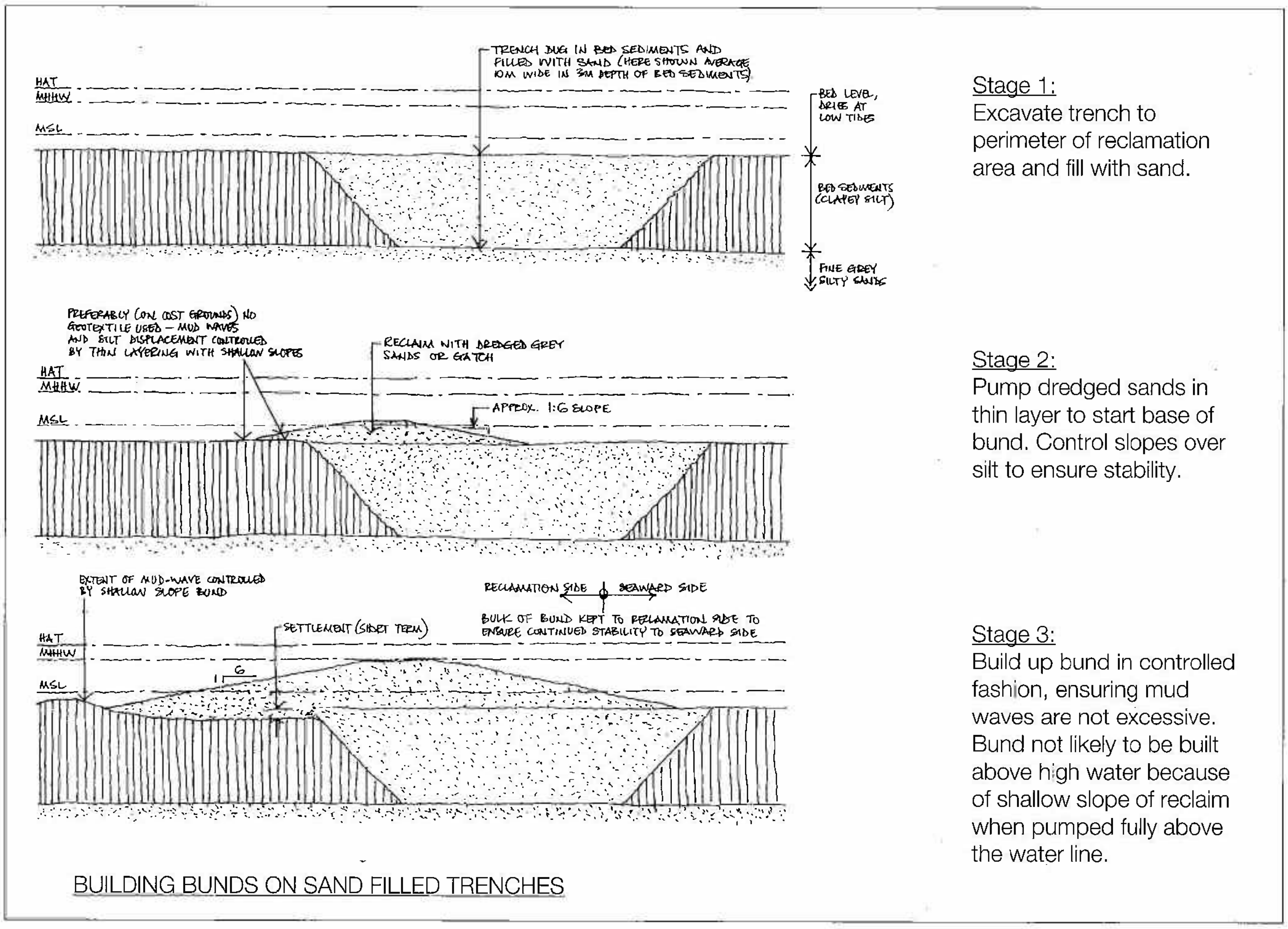


Fig 8.4 Method for reclamation over sand strata to form new islands

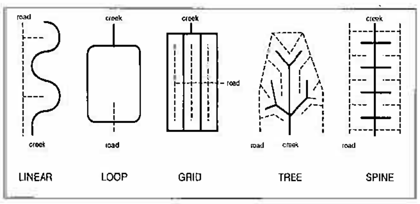


Fig 8.5 Guidelines for creek networks: each network type affects road layout and requirement for bridges, and has different 'dead end' characteristics

hand, at Al Khiran, it would be necessary to achieve a balance between ensuring adequate flushing and avoiding erosion and danger to leisure activities. Preliminary geotechnical surveys were undertaken for both sites to reveal a strata made up of calcareous silty sand overlying gravelly sand at Al Khiran, and soft clayey silts underlain by cemented sands (gatch) at Al Shuwaikh. It was important to take advantage of deep sand strata either close to or at the surface providing good foundations and fill material. At Al Shuwaikh, where the sand was overlain by soft silts, it was proposed that the first phases of reclamation development should be carried out in areas where the silt layer was relatively thin. This would be stripped and replaced by dredged sand which would be built up to form the new islands *(Fig 8.4)*. Consideration of this was important in developing conceptual layouts, in order to keep dredging and earthworks within realistic limits.

To guide the competing planning teams, a summary report on coastal and tidal engineering aspects of the sites was prepared, together with a set of basic networks for creek and lagoon layout *(Fig 8.5)*. Design guidelines were also provided on navigable waterway widths and channel depths sufficient for navigation and to allow for some initial siltation. It was apparent that there would be some conflict between good creek network design - which would have in dead ends so avoiding potential stagnation - and economic highways design - which would have no bridges. Attention to the detailed hydraulic design of the creeks would minimise this problem.

Competition winners

After exhaustive selection from many well known international planning offices, a final shortlist of five were invited to enter the competition. Entries were submitted in September 1989 and resulted in the selection of joint winners Philip Cox, Richardson, Taylor and Partners of Australia, and The Jerde Partnership of the USA. The two winning schemes were significantly different in approach, but both had many strong points in their favour.

The Jerde schemes for both Shuwaikh Bay

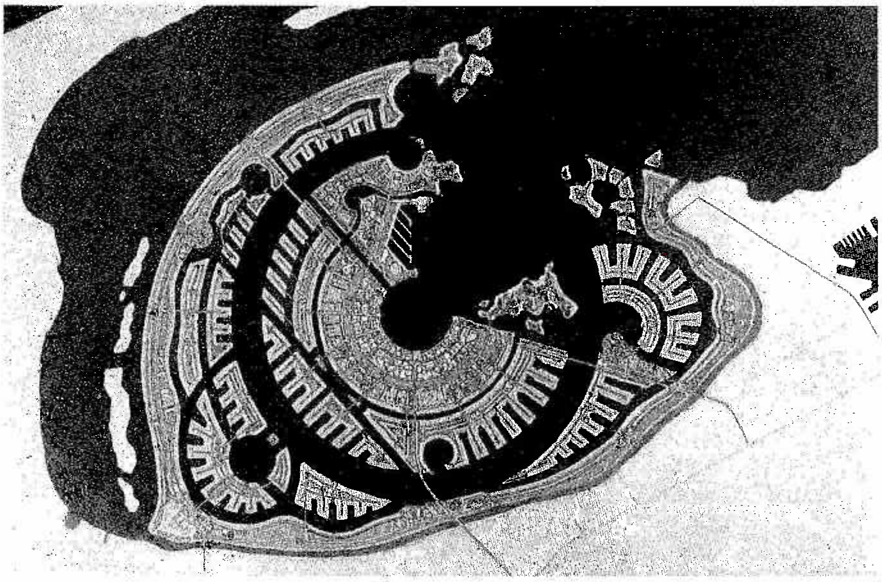


Fig 8.6 a Proposed scheme for Al Shuwaikh (Jerde Partnership)

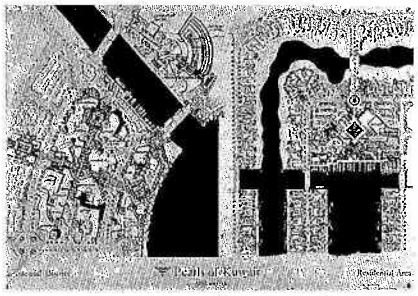


Fig 8.6 b Detail of Al Shuwaikh scheme (Jerde Partnership)

Fig 8.7 b Aerial perspective of Al Shuwaikh scheme (Philip Cox Richardson Taylor & Partners)

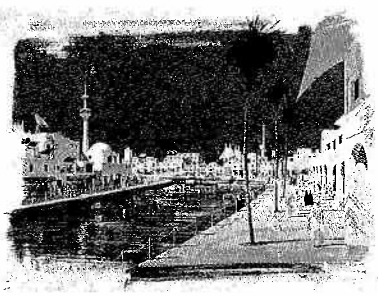


Fig 8.7 a Al Shuwaikh - canal perspective (Philip Cox Richardson Taylor & Partners)

and Al Khiran were of formal composition and boldly urban *(Fig 8.6, a & b)*. The design of the islands for the Shuwaikh site was conceived as a set of concentric arcs, facing out to sea, but linked to the mainland by three main bridges. The main commercial complex would form the core and 'focus' of the development, with clearly defined districts created on outer islands. The hierarchy between public and residential areas was further enhanced by the proposal to create 'gateways' between areas.

By contrast, the schemes put forward by Philip Cox, Richardson, Taylor and Partners were more relaxed and 'organic' *(Fig 8.7, a & b)*. For the Shuwaikh site, the concept of three chains of islands had been developed, each orientated to maintain existing tidal flows. A perimeter water corridor was proposed between the island complex and the existing shoreline of the bay, through which tidal flushing would maintain water turnover, cleansing the bay. A network of mangrove islands was also incorporated in the scheme. These were intended to develop as natural 'filters' enhancing the cleansing of the bay, and to promote wildlife and marine life and provide a 'green' element within views of the bay from residential areas. Design success and engineering feasibility of both schemes were reviewed carefully, with physical modelling used to test their success in terms of hydrodynamics and water exchange.

Development of 'flagship' project

At this stage, in early 1990, it was decided to adopt the site in Shuwaikh Bay as the 'flagship' project. Detailed studies were initiated on geotechnical aspects involving an extensive borehole survey, and on the project's environmental implications, with the objective of preventing or minimising disadvantages and embracing environmental advantages. The studies were to consider the effects of the project both during construction and afterwards, with regard to water quality, mariculture and birdlife. As the Kuwait Institute for Scientific Research (KISR) had previously developed an environmental database for Kuwait, it was intended that KISR should play a key role within the environmental assessment process together with Buro Happold, the appointed management team. Guidance would be provided by Buro Happold's team which, with Professor Patrick Holmes of Imperial

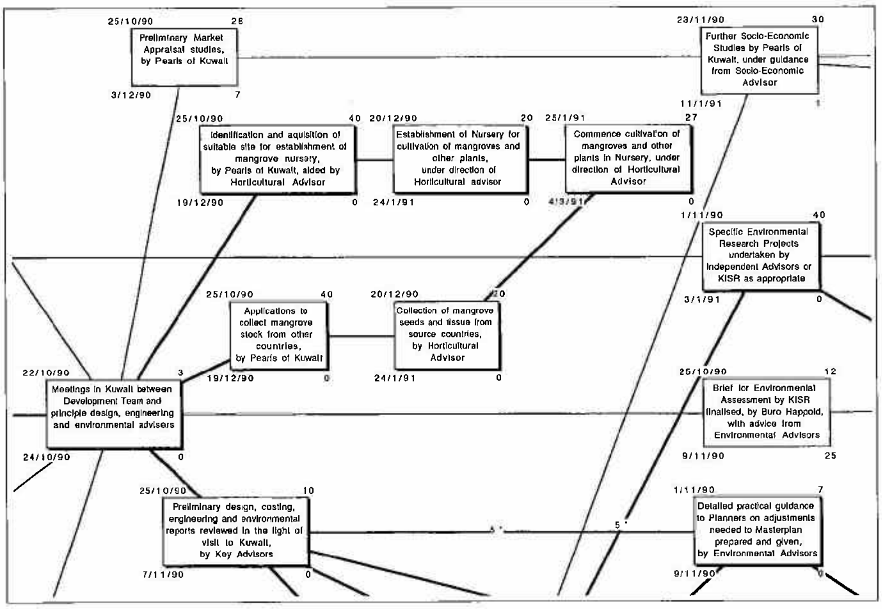


Fig 8.8 Diagram of study management network

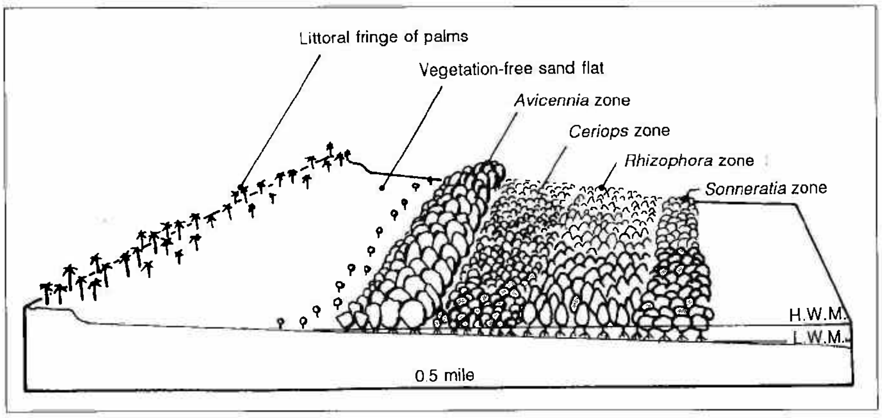


Fig 8.9 Typical zonation of mangrove swamp

College (hydraulic engineering) and Anthony Farmer (mariculture), included international experts who held long-standing relationships with KISR. Other members of the team would contribute advice on specialised aspects of the study, including horticulture, mangroves, mudskippers and birdlife.

The management of what was to be a detailed series of studies, by a sizeable study team, required careful planning. A co-ordination structure was set up, with a detailed project programme to provide a framework within which work could progress *(Fig 8.8)*. Studies were designed to identify: the existing condition of the bay and the continuing or altering status of this if the development never took place; the environmental effects of the development during its construction, and their significance; the environmental effects of the development once completed, and their significance; opportunities to derive environmental benefits through the development; and a means of preventing or minimising problems which might arise.

Introduction of mangrove islands

Studies were however brought to an untimely halt by the invasion of Kuwait by Iraqi forces in early August 1990. Even at this early stage some exciting design possibilities had been brought to light. The concept of creating mangrove islands as nature reserves and as natural filter mechanisms

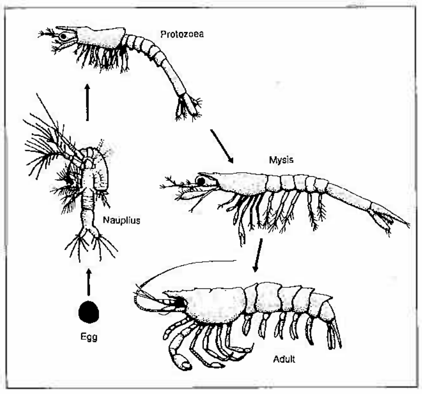


Fig 8.10 Planktonic larval stages of the shrimp

within the marine environment was attracting considerable interest. Successful establishment of mangroves was questioned by some, due to the occurrence of low night-time temperatures in Kuwait during winter. However, others believed - and had some evidence to support their belief - that mangroves had grown in Kuwait in the past, but may have been lost through grazing by camels. It was planned to explore the idea further in the hope of creating islands with a graduated vegetation pattern rising from mangroves at the water's edge to 'dry land' plants such as acacia and tamarisk on the higher inner ground *(Fig 8.9)*. A programme of field research was drawn up to identify source areas from which to collect new plants, ensuring that their growing conditions would be sufficiently similar to those of Shuwaikh Bay, so enhancing the survival of transplanted and propagated specimens. The successful reintroduction of mangroves would bring several benefits. Natural mangrove ecosystems are 'healthy' systems capable of assisting in purification of the existing seawater. They also provide a habitat amongst their roots for many forms of marine creatures, particularly during the spawning stages when young organisms are most vulnerable *(Fig 8.10)*. Cover would also be provided for bird life creating an all-year round green horizon when viewed from other parts of the bay.

Enhancement of marine environment

Previous studies of the existing animal community of the mudflats and silt of Shuwaikh Bay, characterised by mud crabs, mudskipper fish and polychaete worms, had indicated that it was rather impoverished, both in number and diversity, compared with communities in similar situations elsewhere *(Ref 8.1)*. This was largely attributed to three factors - the harsh environmental conditions with especially high summer temperatures

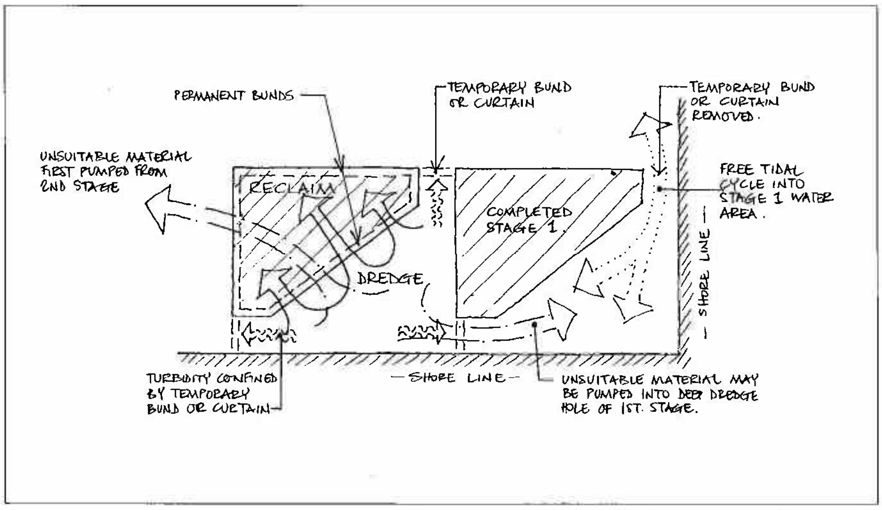
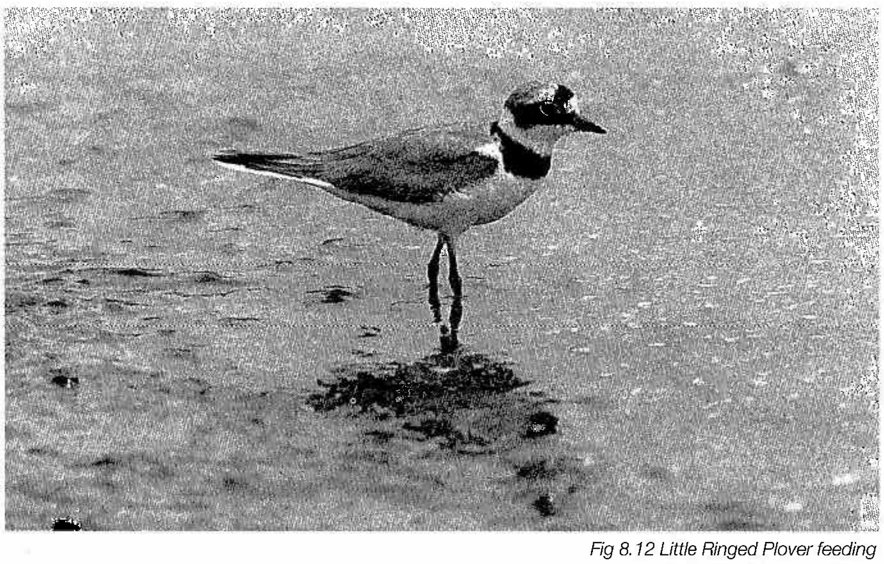


Fig 8.11 Strategy diagram for dredging in contained parcels



Photograph courtesy RSPB, photographer: Dennis Green

Fig 8.12 Little Ringed Plover feeding

and salinity levels, the absence of rocky substrate, and the presence of pollutants. The macrofaunal community was dominated by a few species, living at the limits of their tolerance. As part of the studies, measures were explored for managing and limiting existing sources of pollution. It was thought that the only realistic method for dealing with local areas of pollution would be by stripping and careful disposal of particularly contaminated silt. Improved methods of sewage disposal were being considered at the same time. The possibility of using partially-treated effluent to be flushed through the mangrove plantation areas, bringing nutrients to the plants and keeping salinity levels down, was also being explored.

One of the single most serious environmental hazards to marine life around the coastal waters of Kuwait over the past thirty years, apart from oil pollution, has arisen from unplanned reclamation activities disturbing the prevailing hydrodynamic patterns of coastal waters. The fill materials used were often not stabilised against prevailing littoral drift processes, leading to significant erosion along the edges of reclaimed areas. Development of the construction methods to be used in creating the islands took account of these problems. Furthermore, suspended silt arising during dredging and filling works has the potential to spread a long way, reducing light penetration through the water and thereby harming light-dependent forms of marine life. To counteract this, the suspended silt would be contained within an arrangement of curtaining around work zones, and dredging work would be tackled in sequential 'parcels' *(Fig 8.11)*. These reclamation proposals would also be carefully tested using physical modelling.

The predominance of silt and sand in Shuwaikh Bay and the absence of stable substrates suitable for seaweed growth has prevented the area from becoming a significant prawn breeding ground (KISR 1985). The absence of sea grass, vital for the feeding of shrimp larvae during the first month of their lives has also been a problem. As a solution, the introduction of artificial rocks, in the form of concrete or rip-rap, could provide a suitable substrate on which sea grass could grow, and the creation of sheltered waters amongst the proposed islands would provide a relatively safe shrimp breeding ground. Consequently the marine construction works of the project offered the potential to enhance the environment for marine life and encourage the establishment of a greater diversity of species.

The project was of course suspended by the invasion and occupation of Kuwait. Following the end of the Gulf War there were naturally other pressing priorities, not least mine clearance along the coastline, but the will and enthusiasm remain and it is hoped that the project may once again move forward as the emphasis on rebuilding gains momentum.

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