CIVIL ENGINEERING DESIGN
In the P&S Division Design Group

In 1974 I joined the British Gas Civil Engineering Section, which was led by Mr T C Wilson. The section was part of the Construction Department that was involved in the design & construction of compressor stations and terminals. The first job I was involved in was at St Fergus terminal on a piling contract. This led to working on Wisbech Compressor Station, the first fully designed in-house station. When I was appointed as a Design Co-ordinator for Aylesbury Compressor Station my role changed, as I became involved with all the other design sections as a central figure in addition to my responsibilities as a lead Civil Engineer. Later I was a member of a working party investigating modularisation of compressor stations.

St Fergus

When I arrived at British Gas in 1974 I was assigned to work on the design of the St Fergus terminal. A Civil Contract was in progress on the earthworks and roads [for the station]. Details were needed for a surface water drainage system, fire pond, oil separator, fire water pump system, foul drainage system, cable trenches, etc. I set to work preparing engineer's sketches and designs for the in-house drawing office.

There were several requirements that needed to be met to achieve the design objectives for the surface/fire water system. Oil needed to be separated from the surface water prior to discharge to the Black Water river. The depth of the drainage system was such that all the drainage from the site, including that from future developments, needed to be lifted by pump for discharge to the fire pond. A one million gallon storage pond with fire pumps and fire water supply was needed for the terminal. The retention of the surface water in the pond allowed the oil to separate out, be skimmed off and passed through a tilted plate oil separator, prior to the water being discharged to the river. The bulk of the water left the pond via an under-weir, discharging to the river.

A design was needed for the foul water system from the control complex area. I prepared details for a suitably sized septic tank and aeration beds prior to discharge to the Black Water. The sewage needed to be pumped from a number of locations on the site. A diffuser chamber was incorporated in the pumped flow prior to discharge to the septic tank. Consent to discharge was obtained from the local Water Authority after the details were agreed.

It was decided to run the extensive electrical cable systems about the site in large cable trenches on trays. Conventional reinforced concrete details were prepared for the civil trench work and I decided to incorporate a new resin concrete cover as the most economic solution.

Kirriemuir and Bathgate

At about the same time as St Fergus a number of on-line compressor stations needed to be developed to enable gas from the Northern North Sea to be transported to the South. The pipelines were now being installed very rapidly. I was asked to look at the design of Kirriemuir and Bathgate compressor stations. Again a preliminary civil contract was let, for each of these stations, the civil details being designed in-house. I prepared the layout of roads, earthworks, drainage, etc. for the two stations.

For each compressor station a soil survey and Geotechnical report was produced by Ove Arup and Partners from a brief outlining our requirements. I prepared a brief for our in-house survey section, for the topographical survey, prior to the work being carried out.

Warrington

The Warrington compressor station was launched in 1981 on 9 acres of land, after the design of Aylesbury was completed. I was asked to act as Design Co-ordinator for the new station. The soils investigation report established that the site was very wet and underlaid by layers of very soft clay and peat requiring an extensive drainage system to dry out the site. We were to re-use, where possible the design from Wisbech and Aylesbury. At the conceptual design stage efforts were made to reduce the site area, requiring development by the use of a more compact plant layout.

The station was to have two Rolls Royce RB211 gas generators driving Cooper Energy services compressors. We constructed the buildings out of brick in an attempt to use local labour and reduce cost. Owing to the close proximity of private dwellings it was decided to bury the main process pipework to provide sufficient noise attenuation, experience at Aylesbury indicating that lagging above ground pipework to achieve the same objective was a more expensive option.

During the design of compressor bases at Wisbech I had given thought to the problems associated with large concrete pours. We needed to break the 2-metre deep pour into three lifts to reduce the section thickness, using reinforcement in each layer to overcome the heat of hydration and the resulting shrinkage. A paper was published dealing with "In situ measurements of the effect of partial Portland cement replacement using either fly ash or ground granulated blast-furnace slag on the performance of mass concrete" by P B Bamforth B.Sc MICE of Taylor Woodrow Construction Ltd., 1980. The details of the paper interested me and I decided to make use of the information on the compressor base pour at Aylesbury. The paper suggested that mass pours were possible with reduced heat of hydration and equivalent strengths.

I specified a 70% cement/30% Cemsave replacement mix, the maximum recommended. Cemsave was ground blast furnace slag. The base at Aylesbury was poured with fewer construction joints and reduced reinforcement without any signs of cracking. There was a cost benefit, as the replacement mix was cheaper and reduced reinforcement was used.

Having fewer pours meant that there was a saving on programme time. Thermocouples were included in the base pours at Warrington, to monitor temperature. The results were satisfactory, the 28 day strength being met and the temperature limited to a maximum of 27°C. No cracks were observed on these bases.

The advent of modular compressor stations was signalled in 1983/4 when a working party, of which I was a member, studied ways of reducing the cost of compressor stations. Many good ideas came out of the project. Three modular stations were constructed.

Wisbech

In 1978 it was decided to have a full in-house design for Wisbech and I was given the task of designing the full civil works.

The Wisbech Compressor Station is situated in Norfolk and covers an area of 11 acres. The station houses two gas turbine driven compressors, one of 26,000 horse power with a Rolls Royce RB211 gas generator and a second of 18,000 horse power with Rolls Royce Maxi Avon gas generator. A control building complex houses the equipment for controlling the station.

I prepared the civil design and details for compressor foundations, pits, surface water drainage, foul drainage, roads, radio tower, earthworks, piling, control buildings, compressor enclosures, fire pond, recycle pits, etc. The soil investigation carried out earlier revealed that the site was a reclamation area from the sea comprising of sand-fill. I consulted with Mr Vic Poulton, an experienced Senior Civil Engineer in the section, concerning ground improvement for the major foundations on the site.

I decided to improve the ground under the main structures using a vibro-compaction technique. Plate bearing tests to an ultimate load were performed on the piled areas. The specification called for a limit of 5mm settlement at working load which was easily achieved. There were slight changes in the levels apparently associated with tidal variations. A regular survey to monitor levels was instituted to see if there was any significant change in the compressor base level over a period of one year. This showed the base to be stable. The design of the earthworks and roads presented few problems, the site being almost flat and the sand provided reasonable foundation material.

Drainage water needed to be pumped from the site but owing to the area topography, the Anglian Water Authority were concerned about any additional water entering the complicated outfall system. I considered piping across the dyke wall into the tidal channel but this would be more costly. Finally consent was given for discharge to the local ditch system via a buffer storage to reduce peak flow. All these details were agreed with the local Water Authority.

Following British Gas practice, oil interceptor measures were taken for the site. A large three compartment interceptor was placed on the drainage system prior to pumping. The interceptor was a gravity type with a retention time capable of removing oil globules up to .015 cm diameter for a once-in-one-year storm. Storage of 900 gallons was provided in each of the three compartments of the interceptor. On Wisbech I had the opportunity of making use of the experience gained on the previous stations and designed a new unit that would suit our needs. We needed a uniform flow through the full width of the interceptor. I calculated the flow and retention time needed for a typical site discharge and developed a size suitable for a once-in-in-one-year storm condition. The tilted plate separator packages were considered as an alternative design but cost precluded their use. A 50 gallon unit interceptor was placed alongside each compressor unit for collection of small oil spillages. The large interceptor was a safeguard in the event of high pressure pipework rupturing or seals failing on the compressor, releasing a large quantity of oil very quickly.

The compressor foundation was the main structure on the site. The foundation was combined with the superstructure to form a machinery enclosure with a steel frame and concrete walls and roof. The foundation was formed as a raft with a suitably large block to support the machinery thereon. The block was sized to ensure that the natural frequency was outside the normal operating frequency of the machine. The recycle pits, meter pits, station bypass pit, scrubber foundation, fire pond, radio tower foundation etc. were designed taking into account the appropriate codes and standards.

Surcharge was allowed for in the loadings for pits due to the possible use of cranes and heavy equipment on the site. As the walls of the buildings and cabs were to be tiled it was decided to use a low shrinkage limestone aggregate concrete. The walls were cast, in alternate bays to minimise the effect of shrinkage. A special mortar mix was used to secure the tiles to the walls. Despite these precautions there were a few instances of tiles subsequently cracking but in the main the tiling has remained in good condition.

At that time Mr Frank Turner worked in our design section. I was fortunate in having the benefit of guidance from this internationally recognised expert who advised on the specifications for the concrete mixes to be used on the superstructure for the control complex and compressor cabs.

The machinery enclosure was provided with a travelling crane for removal of the compressor rotor for maintenance. Numerous smaller chain blocks were provided for removal of parts requiring maintenance. I needed to prepare full details of the steelwork for the building including the supports for the craneage and equipment.

I found that I was involved in a great deal of interface work with other disciplines and needed to co-ordinate the work. I visited the local Water Authority to agree the consent to discharge from the site for foul and surface water. A bio-disc sewage treatment plant was installed to deal with the foul water. Electric power for the site was available from a nearby pole transformer. Detail design briefs were needed from each discipline to enable us to ensure we provided for their requirements.

Following the experience gained on Wisbech I was asked to pioneer a new procedure within British Gas for design co-ordination and act as a Design Co-ordinator for Aylesbury compressor station. (Until then the several design sections had individual responsibility to deliver their designs to programme. If delays occurred, responsibility and remedial action became unclear.) This proved to be successful and was adopted on all significant projects in British Gas.

We decide to go modular

Modular construction had developed significantly on off-shore work and some on-shore projects had adopted a measure of modular construction. I was part of the group which carried out a Modular study in 1983/4. I was later part of a working party which studied the possibility of applying modular construction to compressor stations. The study showed that there were advantages over conventional methods in cost, construction time and land area used. Access for large modules would be a problem on some sites. Correct site selection was essential if the proposals were to be adopted. We were asked to look at Huntingdon and Carnforth as potential stations for modular design. Overseas sites were also to be considered, particularly in remote locations where this form of construction would be an advantage. We also looked at relocation of modules from one site to another location.

Huntington

Huntingdon, our first Modular station located on 5 acres of land was launched in 1985. The building modules are sized to be in a range readily available in the prefabricated building market. A performance specification was prepared against which tenderers were to price. By comparison with earlier stations, building size was reduced, equipment being located in a smaller floor area. All individual buildings were close together, which had the effect of shorter cable routes, fewer services, reduced floor areas, etc. Programme savings were possible with off-site fabrication of the buildings. The on-site construction time could be reduced for erection. The factory fitting out of the building with equipment proved to be a problem as the conventional prefabricated building supplier was not capable of this. A separate contract was needed at site to complete this activity.

Carnforth was also constructed as a Modular designed station. The land take area is large on this site due to the topography and the location of the AGI. Selecting a suitable route for the modules to reach the site proved difficult due to the hilly terrain.

Over 18 years British Gas policy for building compressor stations moved from Design/Construct contracts to a largely in-house design with construct only contracts. A variety of building constructions were used moving from on-site assembled systems through concrete and brickwork to pre-fabricated timber with metal cladding. My experience on Wisbech was invaluable giving me a first-hand insight into the design. This served me well when I pioneered the Design Co-ordinator role on Aylesbury Compressor station. The use of a Project Management and Information System, PROMIS instilled a disciplined approach to the design and construction process. The use of networks and resource planning helped put the task in perspective when manning up for the work. The inter-discipline contact gave me an appreciation of the work of other departments.

The modular design presented a new and controversial challenge to all. It was not readily accepted by POD who saw their standards eroded. The less spacious working conditions in the new modules brought home to people the meaning of "fit for purpose". The cost of compressor stations did not vary a great deal over ten years despite inflation. The stations ranged in cost from £11M to £17M. On Huntingdon the use of refurbished machines, less land-take and modular buildings resulted in a very economic station cost.

Drawing office support

The design and construction of compressor stations and terminals was supported by an in-house Civils drawing office and a very able body of men at a multi-discipline contract drawing office, first at Highbury and later at Judd St, headed by Wally Hart from the Design Section.

The in-house civil section was headed by George Dane who later managed the CAD terminals and network at Bishops House. The draughtsmen (and women) were experienced and knowledgeable, being able to produce drawings and details to a high standard, meeting deadlines and programmes for each section.

Later the in-house multi-discipline CAD (Computer Aided Design) drawing equipment was established allowing drawings to be electronically produced from a single electronic model of the station or terminal.

This has been the story of the Civil Engineering design area. The other design sections would have similar histories of challenges and innovative solutions under the pressure of a large construction programme and in-house design.

Sean Coogan, Senior Design Engineer

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