Article category: PROJECT PARADE

PME '99 WINNER –
More than a decade of work justly rewarded

The 1999 winner of the Project Management Excellence (PME) Award, organized by the Project Management Institute South Africa (PMISA), is the Delivery Tunnel North for the Lesotho Highlands Water Project (LHWP). The project was completed three months early and 5% under the originally defined budget – an amazing achievement for an underground project.

The 1986 Treaty between the Kingdom of Lesotho and the Republic of South Africa for the R9bn Phase 1A of the well-known Lesotho Highlands Water Project, established the Trans-Caledon Tunnel Authority (TCTA) as the body for the implementation of the works in South Africa.

In turn, the TCTA appointed engineers to manage and design these works to link up with the tailpond of the hydropower station in Lesotho, being designed by others for the Lesotho Highlands Development Authority (LHDA).

These works became known as the Delivery Tunnel North (DT North). It comprises a 22km long tunnel from the South Africa/Lesotho border to an outfall 8km north of Clarens in the Free State. From the start of the feasibility study in 1982, the management of this massive engineering project focused attention on excellence.

The Project Team

The management and engineering were undertaken by a consortium of SA consulting engineers, Highlands Delivery Tunnel Consultants (or HDTC), comprising:

- Ninham Shand
- VKE Engineers
- Steffen Robertson
- Kirsten and Keeve Steyn Inc.

Construction was undertaken by contractors HMC Tunnelling Venture, a German/Swiss/SA joint venture of Hochtief AG, Marti Inter and Concor.

Environmentally sensitive

The north-eastern region of the Free State where DT North is situated, is renowned for its beauty. However, this also presented the project team with environmental challenges. This area is characterised by scenic cave sandstone cliffs and deeply incised valleys, the most important being the Caledon River as the international border.

The Golden Gate National Park is in close proximity to DT North and numerous archaeological and palaeontological sites of interest exist in the project area. The local communities are rural or small-townsfolk – mainly farmers, retired people, artists and unskilled or semi-skilled workers. Since employment opportunities are scarce, the project generated much-needed jobs.

Milestones

- DT North was planned and designed from 1987 to 1990
- Constructed from 1991 to 1996
- Final commissioning in 1997 and 1998 once water became available from the Lesotho project components.

In operation, DT North is under extreme hydraulic pressures and transfers water in continuous flows from Lesotho across the South Africa/Lesotho border to the upper reaches of the greater Vaal River catchment. This is achieved through its concrete-lined diameter of 4,6m.

In addition to the main tunnel, DT North also included the construction of four access portals and adits, three tunnel spoil dumps, an outfall structure in the Ash River, two de-watering shafts at the Caledon and Little Caledon Rivers respectively and a Tunnel Bypass at the Little Caledon River. This bypass consists of a shaft, tunnel and outlet works.

Various infrastructure projects also formed part of the main contract.

The tunnel traversed all the identified geological horizons and intersected some 20 dykes of varying sizes and water potentials (about 60l/sec inflow). Together with the internal tunnel hydraulic conditions this called for innovative management of lining designs (to resist rock loads and water pressures) and construction techniques.

Commissioning of the tunnel under full static pressure conditions was undertaken towards the end of construction from April to June 1996 with outstanding results of 0,01% water loss over the whole length. As water became available only after September 1997 from the Katse Dam/Transfer Tunnel systems upstream, the flow testing process of the Delivery Tunnel was then enabled. Flows of up to $50m^3$/sec were achieved proving that all the design criteria had been met or exceeded. Specific attention was paid to the effects of these flows on the downstream environments and landowners and the effectiveness of preparatory works by the Department of Water Affairs.

Special management methods

The execution of a bi-national project of the magnitude of the LHWP demanded management of the highest calibre to enhance the prospects of ultimate success. Taking account of the very high proportion of world tunnelling contracts failing to meet time targets and cost budgets (mainly due to underground unknowns), the project team drew together experts of international and local experience and repute, to address the many unique technical, contractual, practical and managerial challenges faced.

The management process adopted to meet these challenges can be summarised in the principle of *Integrated Project Management by Team Building* embraced by HDTC**.** At the highest level, this is reflected in the effective management teams formed with TCTA and HMC respectively, but the approach filtered right down to the lowest orders of inspectors/foremen on the site.

Scope and time management

The project was conceived in the 1960s as the Oxbow Scheme, with a yield of about $10m^3$/s. The concept progressed through several developmental phases. These culminated in the extensive feasibility study for the LHWP before the South African and Lesotho governments in 1986, by way of the Treaty, agreed to the implementation of Phase I. This was based on an ultimate yield of $70m^3$/sec, with Phase IA delivering about $18m^3$/sec and IB an additional $12m^3$/sec. The scope of this tunnel provided for the full Phase I delivery of $30m^3$/sec.

Contract TCTA-01 for the tender design of the Delivery Tunnel commenced in May 1987 with a key completion date of September 1990. The goal was to achieve award of the various main construction contracts at their designated key dates such that implementation in terms of the Treaty was not delayed by any of its components. Detailed and accurate planning and costing were required, but timeous completion within the various milestones set was essential to ensure achievement of the goal from both a technical and financial point of view.

Contract TCTA-10 for the Detail Design and Construction stage commenced in November 1990. The Work Breakdown Structure (WBS) for the detail design (in Johannesburg) and the WBS for the construction (in the north-eastern Free State) were tightly integrated to achieve the various component milestones, as well as the overall key completion date. In accordance with the Contract, this was set at December 1996

Within these two structures a number of substructures clearly also played a major role. These included early provision of infrastructure for about 1 200 personnel, staff mobilisation and demobilisation, environmental developments, specialist civil, geo-technical, mechanical and electrical designs, construction/manufacture and installation and, finally, commissioning of the works. Due to the nature and duration of underground construction, the management plan also had to accommodate a certain amount of flexibility in order to deal with changing circumstances. These included geological surprises, political, legislative and technological changes, or advances in construction methods.

The management plan had as its basis planning, assessment, implementation and review. Co-ordination and liaison was mutual to all these components and was achieved by transparency at all levels, be it in documentation or in meetings that covered the entire spectrum from technical, contractual and financial to environmental and insurance issues. Vehicles used in the plan included time management, method statements, procedures for work and quality assurance. Whilst day-to-day informal interactions across a wide spectrum of issues and parties to the wider project became essential to maintain short- and long-term control of work-scope, the regular co-ordination provided a solid formal framework.

Maintenance-free end-product

One of the client's requirements was that the end-product should be maintenance-free as far as possible. The site is remote, mainly underground, and therefore difficult to access. Maintenance inspections would therefore be undertaken on five to ten year intervals in the long-term only. Shutdowns for maintenance work are also very costly and were to be minimised if not avoided. To this end, the design and specifications were always balancing quality (mainly durability in this case) with affordability.

On management level, quality management included discipline-related action, procedures and audits and a number of other management tools were used.

- Review of work by panel of experts (HDTC Board) consisting of experts with a wide variety of expertise in the fields of geotechnics, tunnel lining and M&E design, contracts and management;

- Visits to similar projects by key staff and peer reviews;

- Inter-disciplinary meetings (for example between design and construction staff) on a monthly basis to exchange information, discuss and solve problems and to improve or clarify methods of work;

- Documentation control, which included improving access to information and securing of data in the case of disaster, pioneering an electronic document-capture-and-retrieval management system;

- Encouragement of staff to complete technical papers, ensured that self-criticism of work done and the management of records and documentation was perhaps a little closer to home than would possibly have been the case otherwise,

- Annual technical/contractual audits by external auditor, reporting directly to the HDTC Board. This was in addition to the regular financial audits conducted as a matter of course.

Welding together an effective team

The challenges of welding together an effective team and engendering a team spirit in consortia are well known. This is often particularly difficult where professional jealousies exist and proprietary information of member firms is at risk. The management group on DT North effectively countered these potentially disruptive tendencies with full backing of the HDTC Board. Examples of pro-active steps taken include:

- Promoting a corporate HDTC image through distribution of logo-embossed clothing to all staff, either free-of-charge or at significantly subsidised rates;

- Frequent informal site and office get-togethers with senior staff and managers from parent firms, demonstrating commitment to the common causes of HDTC;

- Non-partisan approach in distribution of new work among the staff: the "best person for the task" approach was adopted within the framework of the consortium agreement on % inputs. Nevertheless, after more than eight years the process had been so effectively managed that actual % inputs came within 0,7% of the agreement figures.

- Hosting of workshops, study tours or project visits (in the case of senior staff this included overseas visits to appropriate projects and conferences), and

- Provision of recreational facilities and events on site and subsidised meals at the communal mess.

- Involvement of staff in aspects not directly their responsibility thus providing opportunities for personal growth and general expansion of expertise. A good example of this is the allocation of TBM functions to staff in other sections on site whose workload was at a cyclical low.

Quarterly reviews of the status of each team member were compiled, using the current project time and cost schedules applied to the developing project requirements. Staff assessments/performance appraisals were done annually and feedback given. Staff development was provided for members to attend training courses on an annual basis as dictated by their particular circumstance.

Three levels of communication

Project communications took place at three levels. The first was internally as part of the internal HDTC management system. The second was project-related by or with HDTC. The third was externally through visitors to site, conference papers/presentations and publication of news articles. Internal HDTC communications were managed through staff meetings, events, workshops and technical meetings.

Project-related communications were effected formally through the various meetings and on the typical annual calendar of meetings. Much of the effective communications also occurred telephonically or by facsimile or e-mail on a daily basis. This was achieved through the network of personal relationships established and cultivated over such an unusually long and geographically extended project.

External communications were managed by the project manager and delegated where appropriate. A total of some 30 papers and 40 articles were published. In addition, HDTC motivated the conversion of an old farmhouse on the site to visitors' centre. Once approved and equipped, it was operated for the first two years by HDTC. They also provided the public relations officer initially, who established the centre as a real asset.

Apart from serving the more formally arranged groups and tours, the centre became popular locally as well as in the wider region. Some 300 persons per month (average) visited the centre over the busy years of construction. A highlight for most visitors in small groups was the 6 or 7km train ride up the tunnel to the real Tunnel Boring Machine (TBM). Here, they experienced the atmosphere and almost factory-like conditions in this massive piece of machinery.

Project environmental management

DTN was developed in a sensitive and picturesque natural environment and in communities with a delicate social fabric. Although conducting an Environmental Impact Assessment (EIA) was not a statutory requirement when the design of the project commenced, the TCTA accepted this responsibility. They commissioned HDTC to undertake an environmental assessment of the delivery tunnel as part of the planning and design phase of the project.

An environmental officer was appointed to the construction site on the chief resident engineer's staff. Although the project manager remained ultimately responsible to ensure that environmental matters received the required attention, the day-to-day implementation of the environmental plan remained the responsibility of the environmental officer on site.

The "Delivery Tunnel North Environmental Management Plan" (EMP) was developed to ensure that all the legal requirements and proposals for environmental management as contained in the EIA and the specifications, were met. To this end, surface-water quality, ground water, noise and dust and site disturbance were selected as the most important aspects to be monitored. While monitoring on the important environmental aspects was scientific, the monitoring on matters such as disfigurement of natural areas, disruption of the daily lives of communities, etc,

relied largely on the experience of the environmental officer.

A rehabilitation plan was developed to rehabilitate all the areas disturbed by construction activities (both permanent and temporary works), such that they would be erosion free and not degrade the future potential of the land. This philosophy required that all site installations be removed, buildings demolished and all concrete slabs or foundations be broken up and removed to designated spoil dumps. Here, the spoil was covered with fine material, a layer of topsoil applied and ultimately grassed. Detailed landscape designs were carried out and the contractor was required to reshape areas to prescribed levels in sympathy with the existing natural landforms of the area.

Few environmental problems occurred on DT North mainly due to the environmental management system. This provided for early environmental input into decision making, and the obligatory environmental review prior to implementation of method statements and site establishment designs. The problems that did occur were dealt with timeously. Through appropriate channels and progress with corrective action, they were continually under the scrutiny of the environmental monitoring committee.

Although this contract predated statutory requirements by some years, the strategy followed on this project is similar to the process of Integrated Environmental Management promoted by the National Department of Environmental Affairs and Tourism at the time. Furthermore, it is compatible with the systems proposed by the ISO 14 000 Standard although also predating this by several years.

The success of the above management of the environment can be gauged by the DT North project receiving in 1998 the prestigious **National Premium Award for Integrated Environmental Management** allocated annually by the SA Environmental Planning Professions Interdisciplinary Committee (EPPIC). The contract was also highly commended with a Certificate in the Fulton Concrete Awards in 1996. Furthermore, the visitors' area at Ash Outfall received a National and Regional Award from the Concrete Manufacturers' Association in 1998 for paving and "soft" treatment in a harsh environment.

Past and Future

The project has been fully operational since its inauguration by President Nelson Mandela in January 1998. HDTC was then also instrumental in establishing the operations and maintenance team and relevant procedures to ensure that the past success is perpetuated.

The outcome of the pro-active and enlightened management approaches adopted for the Delivery Tunnel North section of the Lesotho Highlands Water Project, has been the completion of a project remarkable for its engineering excellence, economic execution, as well as responsible treatment of environmental impacts and local community relations.

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