Clacton Town Centre Flood Relief Sewer

important role of geotechnics throughout the scheme

Clacton is a large seaside town with a Victorian combined sewerage system. During times of storm sewage overflows from the trunk sewers and is discharged into the sea on bathing beaches. The Clacton Town FW Relief Sewer, which soon became known as the Clacton Clearwater Project was designed to intercept these discharges and to construct a new trunk sewer to the sewage treatment works at Holland Haven. The tunnel has been constructed of sufficient capacity to act as a storm storage tank with discharge being controlled by pumps. At the works it is screened and discharged down a long sea outfall. Further treatment will be applied here in the near future as part of the Urban Wastewater Directive.

The majority of the work consisted of a 2.1m diameter tunnel stretching 4.13km from the pier to the Country Park. There was also 198m of 1.2m diameter tunnel driven by hand to make connections to the town sewers at Anglefield and 396m of 3m diameter tunnel driven by hand to join to the pumping station at the STW. The main tunnel was driven by a Lovat M101 EPB machine using Buchan trapezoidal segments fitted with gaskets and fully bolted and grouted in place. During construction, the world record for this form of construction was broken seven times. Despite that, there was not one accident during the tunnel phase and quality was not compromised.

Horrendous problem

The start of the scheme had been delayed due to a horrendous public relations problem based on expected loss of trade and the stability of the clay cliff along the Seafront. The public relations issue was handled by the appointment of a dedicated PR Manager who manned an information centre located in the town to deal with all complaints.

The Geotechnical aspects were handled by A F Howland Associates who had two experienced members of staff permanently on site monitoring the stability of the cliff and advised the team on possible problems.

Geotechnical

During the early stages of the Clearwater scheme it became apparent that geotechnics would play an important role due to the proximity of a potentially unstable London Clay marine cliff located in an area with a history of recent slope failure. As the project developed this role evolved and continued throughout construction. A F Howland Associates (AFHA) – who have the long term tender for carrying out all Anglian Water ground investigation and providing a geotechnical consultancy – became involved in May 1995 when the main ground investigation was carried out. At this stage the work included: approximately 150 cable percussion boreholes, most with standpipe piezometer installations; a comprehensive laboratory testing programme which aided production of a site classification for the London Clay; a geotechnical report which included the recommendation of construction techniques to minimise the risk of aggravating pore water pressures, or other potential slope failure triggers; a preliminary assessment of settlement; an understanding of the hydrogeological influences.

The investigation and researches highlighted the following principal problems:

- marginal stability of the cliff and the potential for the tunnel to aggravate the instability;
- presence of a deeply infilled scour channel within the London Clay, infilled with water bearing granular deposits. Its presence was a potential hazard to tunnel construction.

The initial assessment was that the scheme could be safely carried out, but due to increasing public concerns it was necessary to prove **'beyond all reasonable doubt' that the tunnel would not compromise the stability of the cliff.** A difficult task when natural periodic cliff failure had occurred in the recent past, in the absence of a tunnel. If a slip had taken place during construction, it was necessary to:

- prove that the tunnel was not in some way to blame;
- reduce delays to construction;
- avoid possible abandonment of the scheme.

AFHA recommended further phases of investigation. Firstly it was necessary to define and conduct further analysis and develop a deeper understanding of the slope processes and trigger mechanisms. Secondly, if a landslip were to take place, then safety measures needed to be in place to prove that the tunnel had not caused the failure or indeed had not caused any significant effect on the ground.

Further analysis included:

- extensive limit equilibrium analysis at surveyed cliff profile positions and 'state-of-the-art finite element analysis. Both involved development of a model and sensitivity determinations which included the variation of soil and groundwater conditions, soil parameters, cliff geometry, cliff recession of the natural (undefended) slope, influence of sea defence construction, position and size of tunnel, stiffness of London Clay, the effect of beach erosion;
- comprehensive settlement analysis and assessment of the settlement trough, with production of contour drawings;
- researching the history of construction of the buildings along the sea front that lay within or close to the settlement trough;
- surveying the condition of the seafront footpaths, walls, railings, promenade and other hard standing, and morphology of the cliffs;
- obtaining an academic perspective on the form of cliff failure from Professor J N Hutchinson.

The finite element analysis produced an understanding of the magnitude and distribution of strains in the ground as a result of future tunnelling works. It established an optimum position (line and level) and tunnel size to ensure safe construction. The analysis also produced a maximum grouting pressure to use during tunnel lining.

The 'safety measures' put in place to show that construction could not have caused a 'natural' landslip included:

- installation of approximately 140 inclinometers and 70 pneumatic piezometers, which were monitored before, during and after construction located in what was predicted to be a stable block of ground between the tunnel and the cliff;
- 450 crack gauges were installed;
- reassessment of the conditions survey before and after the tunnel had passed by.

AFHA provided full time site supervision during construction to monitor the instrumentation and interpret any variations from the base line conditions.Methods were also devised, as part of an ongoing liaison with Anglian Water, to prove that construction procedures were not compromising cliff stability. A programme of sampling and laboratory testing of soil removed during tunnel excavation was also implemented. This showed that the ground conditions encountered during the tunnel drive were as predicted by the original ground investigation.

Clacton - recovery of Lovat 101 machine
(courtesy Anglian Water Services Ltd).

Planning & programme

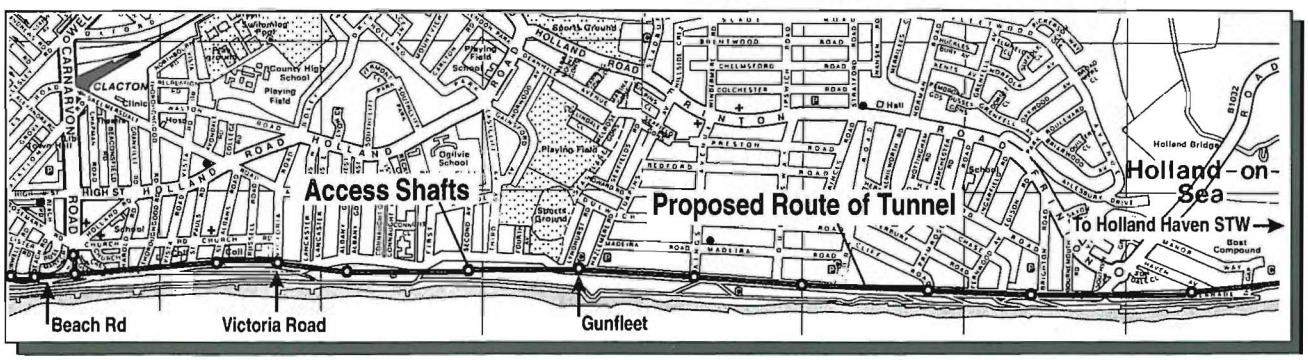
Even before the contract was let it became apparent that, without substantial planning, time could never be regained on the programme. The need to increase the rate of tunnelling to regain six weeks float in the programme led to the decision to increase the passing points on the railway, increase the length of trains and enhance the pit head arrangements to get rid of muck and prepare segments. The inclusion of a Planning Engineer in the site team from day one shows the importance of this function to the contractor. The success of these measures coupled with a little luck led to the establishment of a world record of 37m in a twelve hour shift. In fact the target of achieving a six week float in the programme was doubled and substantial completion guaranteed at Christmas 1997.

Project management

When looking back at the reason for success on this project it would be easy to say that it was due to the partnership with AMEC Tunnelling. Whilst that decision was very important, true success came from concentrating the project management at site level. This was coupled with the adequate resources used by both parties and the form of contract finally negotiated. All these elements were essential for the success of the scheme.

The Partnering Agreement negotiated had a very clear focus on a completion time with a considerable cash bonus. The Agreement modified the contract from a fifth edition Civils to a Reimbursable Cost with Target and allowed the client's project manager to be seen to generate a profit for his company for the first time. The profit from meeting the target was shared equally between the partners. This ownership of

Clacton - tunnel line about 15m from cliff edge
(courtesy A F Howland Associates).



Clacton - map shows proposed route of tunnel (courtesy A F Howland Associates).

the scheme by the stakeholders was fundamental for success of the project.

Cost control

With the signing of the Partnership Agreement with its move to cost reimbursement, it became obvious that considerable work was necessary to check the monthly valuations. To increase the client's site resources an independent cost consultant was appointed from the firm of Faithful & Gould. As the contractor's quantity surveyors was performing a similar role for AMEC the information was combined into one report. This joint role of cost role and prediction by both parties was crucial to the containment of cost, to allow a profit to be made. It has also hastened the agreement of the final account which will be submitted at the end of March 1998, completion date for the contract.

Conclusion

At the beginning of December 1997 a full days session was held to discuss the lessons learned from the job. All team members were reassembled and their thoughts recorded along with their recommendations. The same project management style will be adopted for Project Orwell, at Ipswich, which was due to start at the end of March

Note: The Editor & Publishers gratefully acknowledge the cooperation of Adrian Henderson, Anglian Water Project Manager; Gill Bond, Geotechnical Engineer and Dr A F Howland, Principal of A F Howland Associates in producing this edited paper on the Clacton Town Centre Relief Sewer.