Highlights:

- LTA’s Safety Culture
- Geotechnical Instrumentation in Deep Excavation Works
- Safety Control Process for Deep Excavations
- Rebuilding Nicoll Highway
- Enhanced Safety Features for Realigned Nicoll Highway Station and Tunnels
- UK’s Construction (Design and Management) Regulations
- Safety Pledge for ASAC 2005
Introduction

For a strong corporate safety culture to develop in any organisation, every member of the organisation, from the chief executive to the officers on site have to play a part. Everybody should share the responsibility for safety and work towards achieving the safety objectives. Good safety performance requires clearly defined roles and accountability that are aligned with the Safety Policy to achieve its goals.

Safety Leadership

This is outlined in LTA’s Safety Policy. We will “strive for the highest standards of safety consistent with international best practices. We strongly believe that every accident is avoidable and we aim to achieve zero accidents for all our projects”.

Along with the Chief Executive of LTA, the Deputy Chief Executive and the Divisional Directors set the direction through the Corporate Safety Committee, with the Occupational Safety and Health Management Manual as the principal guiding document.

At the project level, project safety committees are formed for every major project under the leadership of the project directors. There are currently six committees in LTA for management of occupational safety and health.

Dialogue sessions between the senior management of LTA and the major project contractors, chaired by Director, Projects, are held twice yearly to review past safety performances, good safety practices, and share their lessons learned for dissemination to others.

Safety Promotion

LTA recognises the need to encourage contractors to be pro-active in implementing occupational safety and health practices on their work sites. In 1999, LTA launched the Annual Safety Award Convention to give due recognition to contractors who have demonstrated excellent safety performance.

Similarly, due recognition is also accorded to LTA officers for their efforts in managing occupational safety and health on the work sites. Currently there are two schemes:

♦ Individual staff level: Construction Staff Safety Award for the most safety conscious officer from each project team.
♦ Project team level: Project Safety Commendation Award for the best performing project safety committee.

Safety Engineering

Throughout the years, LTA has continually upgraded its occupational safety and health requirements in its contract documents based on lessons learned from completed projects. For example, from 2001, LTA officers enforced enhanced requirements for all cranes working on its projects to improve site safety. The results were immediate and there had been a marked reduction of crane-related incidents. As a responsible developer, LTA recognises the importance of safety and has stipulated requirements over and above the statutory requirements for its projects.

Hazard evaluation and risk assessment are requirements during the design, tender evaluation and construction stages. Submission and approval of method statements that outline the logical and safe work sequence and the risks involved are required before the commencement of every work operation during construction.

Safety Information System, an in-house online database system was implemented in 1998 to capture details of all accidents and incidents in LTA work sites. The objectives are to promote transparency of lessons learned, and monitoring of statistics and trend analysis. Contractors are also encouraged to report “near-misses” so that lessons learned could be shared to prevent the occurrence of accidents. Plans are underway for its revamp to a fully web-based system that incorporates other useful data.

Safety Education

In 1999, a quarterly publication entitled Construction Safety News was launched to promote sharing of knowledge. It is distributed widely to LTA staff and contractors, educational institutions and prominent safety professionals in the industry. In 2002, a Construction Safety Handbook was issued to every LTA site officer and contractor’s site supervisor and foreman. From 2005, the Construction Safety News is renamed as Safety News and will provide wider coverage of safety matters.

Major incidences are reported, fully analysed and presented to the Project Engineering Committee and these are cascaded down to all sites as a continual learning process.

Since 2000, LTA project management staff are required to attend an in-house construction safety management training course to equip them with the necessary knowledge and competencies. This course has now been extended to contractors’ staff. In 2003, four specialised safety training modules were also launched to enable staff to gain knowledge in specific construction activities on the various codes of practice, e.g. lifting, excavation, scaffolding, temporary electrical installations, tunnelling, site audit and accident investigation.

In-house safety workshops are held every quarter to promote sharing of information, experiences and lessons learned from challenging or interesting projects.

Safety Department also maintains an intranet safety website that is also accessible by all LTA staff.
Safety Enforcement

There are four main types of safety inspections that LTA officers conduct jointly with each contractor:
- Weekly: Led by the Senior Project Engineers
- Monthly: Led by the Project Manager
- 3-monthly: Led by the Senior Project Manager
- 6-monthly: Led by the Project Director.

In addition, there is an annual internal audit conducted by LTA Safety Department on the project management team as well as the contractor on the implementation of LTA's occupational safety and health management system.

In 2004, the Safety Performance Scheme was implemented for Circle Line Stages 4 and 5. It is a “carrot and stick” approach that LTA believes will lead to better safety performance through more effective self-regulation on the part of contractors.

Safety Performance Statistics of LTA

Since 2001, LTA’s accident frequency rate has consistently outperformed the construction industry’s safety performance figure. In 2004, the LTA’s accident frequency rate reached the lowest ever – only 1.9 accidents per million man-hours worked, compared to the construction industry figure of 3.0.

However, the severity rate for 2004 was in sharp contrast to the construction industry figure of 536 at 1,049 man-days lost per million man-hours worked, mainly due to the unfortunate loss of four lives in the Nicoll Highway incident. Otherwise, since 1999, the severity rate in LTA projects has consistently been better than the construction industry figure except for 2002.

Summary

Over the years, LTA has continually strengthened its commitment to develop a strong and sustainable safety culture in its quest for safety excellence. But this may only be achieved with the cooperation of its contractors, trade associations and professional institutions to realise its goals. As part of the Annual Safety Award Convention programme, LTA's contractors have come forward to reaffirm their safety commitment by endorsing the Safety Pledge as follows:

“We accord the highest priority to safety in our construction and project works.

We believe that every accident is avoidable and we will strive to eliminate unsafe practices on worksites and in the process work towards zero accidents.”

by Tan Hock Seng Andrew
Senior Construction Safety Officer
Introduction

In highly built-up areas of Singapore, deep excavation works are now the norm in most infrastructure and building projects. When carrying such construction activities, ground movement have to be minimised so that the integrity of structures and buildings in the vicinity are protected. It is therefore paramount that the safety of the excavations, the nearby buildings and the public be ensured by monitoring movements, settlements, water draw-downs, etc.

Purpose

In deep excavation work, the use of geotechnical instrumentation is an essential tool for monitoring the behaviour of the works. The data collected can also be used to compare actual movements against design predictions.

Instruments Used

A comprehensive instrumentation and monitoring scheme is normally implemented for safety in deep excavations. The instruments will generally include:

✔ Strain gauges and load cells to measure strut and ground anchor forces.
✔ Inclinometers to measure lateral ground and wall movements.
✔ Piezometers of the vibrating wire type and water standpipes to measure ground water pressures.
✔ Settlement markers to measure ground settlements.
✔ Optical prisms, electro-level beams and tilt-meters to measure building/structure movements.

Protection to Instruments

It is vital to provide protection to these instruments from damage as this could lead to intermittent or complete loss of acquisition of data.
Direct-Reading and Real-Time Monitoring

Instrumentation readings can be collected locally or using data-loggers to provide real-time monitoring for critical areas of the construction to ensure greater safety on site.

Effectiveness of Instrumentation

In order for such a comprehensive instrumentation scheme to be effective, it is essential that the following rules be observed:

✔ The instrumentation must be installed properly.
✔ The readings must be taken and recorded properly.
✔ The readings must be interpreted correctly.

Any signs of abnormal ground movement must be communicated immediately to all parties involved in the construction so that effective remedial actions can be taken in a timely manner or contingency plans activated.

Role of Specialist Instrumentation Sub-Contractor and Civil Contractor

The specialist instrumentation sub-contractor and civil contractor must play complementary roles to make the instrumentation scheme effective.

Specialist instrumentation sub-contractors must:
✔ Have a good understanding of the functions and purpose of the instruments.
✔ Calibrate all instruments regularly in an approved laboratory.
✔ Install the instruments properly and in accordance with manufacturers’ recommendations.
✔ Use proper tools and materials during installation.
✔ Understand the importance and meaning of the readings provided by the instruments and their relationship to the pre-set trigger values and the pre-set reading frequencies.
✔ Prepare good informative and easy-to-read reports during the progress of excavation and any other areas being monitored.

Civil contractors must:
✔ Train staff regularly to update them on geotechnical instruments.
✔ Communicate with all involved parties about the locations of the instruments and request that they not be disturbed.

LTA Geotechnical Database

LTA has maintained a geotechnical database where geotechnical data collected from all LTA major road and rail projects are stored. Soil property data collected from soil boreholes on LTA projects is also stored in the database. From the database, a comprehensive geological map of Singapore can be produced.

Enhancements on Geotechnical Activities

LTA will be awarding direct instrumentation and monitoring contracts for all major projects instead of making them part of the main civil contracts.

There are also plans to share the information stored in the LTA geotechnical database with LTA contractors and Qualified Persons working on LTA projects. In addition, a feature called the Autoloader will be made available to the instrumentation sub-contractors so that they can load data directly into the geotechnical database.

Conclusion

For a geotechnical monitoring programme to be effective, there must be a series of activities such as pre-construction surveys of the buildings and identification of locations of ‘live’ utility services in the vicinity of the site. It is also advisable to take adequate number of underground soil samples at various locations for a clearer understanding of ground conditions likely to be encountered.

A good instrumentation scheme will require the services of a competent specialist contractor with adequate resources and commitment.

The project leader must be prepared to take immediate remedial action and also activate an emergency response plan when soil movement readings exceed pre-determined values to minimise damage to life and property.

by Seetoh Hon Hoy
Senior Principal Technical Officer
Civil Design Department
Introduction
A substantial number of LTA projects such as the Circle Line and the Kallang-Paya Lebar Expressway involve deep excavations which must be safely supported by temporary earth retaining structures to control and prevent excessive ground movements. All LTA sites practise a system of checks with permits for excavation to proceed, at each level.

Safety Control Process before 20 April 2004

Prior to the Nicoll Highway incident, the contractor would seek permission to excavate to the next level by submitting to LTA a request for inspection (RFI), signed by his site engineer. The request for inspection had to be accompanied by the Temporary Works Loading or Removal Certificate – Form QAF/158, and confirmation that the instrumentation readings were acceptable. Two persons were required to endorse the Certificate.

At a site such as Contract 822, a “build-only” contract, the request for inspection had to be approved by the Resident Engineer of LTA.

Safety Control Process after 20 April 2004

After the Nicoll Highway incident, the request for inspection (RFI) must now be accompanied by the Temporary Works Loading or Removal Certificate – Form QAF/158 (Revision B) and three other forms.

The modified QAF/158 form now requires three more persons, representing the building contractor, to endorse it. The objective is to have the main contractor declare that the construction work is done in accordance with the latest construction drawings, thus strengthening the construction safety control process.
The three additional forms are:

✔ Annex C – Temporary Works Inspection & Approval Records;

✔ Annex D – Ground Movement Assessment Record;

✔ Permit to Proceed with Excavation Work.

The objectives of the two annexes are self-explanatory as these are the regulatory requirements of the Building Control Authority.
The Permit to Proceed with Excavation Work is an internal LTA requirement. The objective is to place greater emphasis on ground movement monitoring instrumentation readings. It requires the readings to be obtained and checked against the various alert levels. The Permit carries the endorsements of six signatories, one from the building contractor, one by the Professional Engineer for Design and Supervision, and three from LTA.

Safety Control Process following Committee of Inquiry Report

As the Committee of Inquiry progressed, LTA took steps to strengthen the control process for safety where necessary. By the time the Committee of Inquiry final report was released, there was little that LTA needed to do to comply with the COI recommendations.

Early Compliance with Mandatory Requirements by LTA

Contract 822 had been following closely the mandatory procedures for deep excavation work as described above. It was one of the first LTA project sites to have the Ministry of Manpower’s stop-work order lifted as it was able to demonstrate compliance with the revised procedures.

Subsequently, the strengthened safety control process was practised on all LTA project sites.

Editor’s Note
At press time, the Building Control Authority is in the process of revising Annex C and Annex D.
Introduction

On 20 April 2004, a section of cut-and-cover tunnel of Contract 824 (C824) near Nicoll Highway collapsed. The incident happened when a section of tunnel being excavated to a depth of 30m collapsed, affecting an area of approximately 100m x 150m in size. This resulted in the closure of Nicoll Highway to all traffic for nearly 8 months.

For safety reason, it was decided that this section of Merdeka Bridge be demolished and rebuilt on a new foundation of bored piles for greater stability. This will also minimise the impact of soil movement to the highway and bridge during future tunnelling work in this area.

Sequence of Rebuilding

The following describes the sequence of work for the rebuilding of Nicoll Highway:

1) Stabilisation of the collapsed area with foam concrete and lean concrete.
   Foam concrete and lean concrete were used to fill up the cavities underneath the collapsed area to prevent future subsidence/settlement of the surrounding area.

2) Removal of debris prior to back-filling.
   Debris, where possible, such as cranes, excavators, generators, struts, etc were removed so as to minimise obstruction to future tunnelling works in the area.

3) Strengthening of the temporary staging access with additional ring beams.
   Two additional ring beams were installed prior to back-filling to enhance the integrity of the temporary staging access structure.

4) Back-filling of the collapse area up to the ground level.
   Back-filling was necessary so that a firm working platform could be formed for the reconstruction work.

5) Demolition of Spans 1 and 2 of Merdeka Bridge.
   Two spans of the Merdeka Bridge were demolished to prevent undue stress on the bridge should there be further ground movement.

6) Installation of bored piles for Merdeka Bridge and Nicoll Highway.
   A total of fifty-six bored piles were installed in order to support the road-bridge interface structure to prevent its movement during future tunnelling or excavation work in this area.

7) Construction of superstructure of Nicoll Highway.
   After completion of superstructure, street lighting and other finishes, prior to opening the roads to the public, the Nicoll Highway was subjected to the LTA’s in-house project safety review process for road projects.

Safety Precautions and Procedures

In order to rebuild the Nicoll Highway in a safe and timely manner, C824 Nicoll Highway station project team worked closely with LTA’s Safety Department and the contractor to implement a comprehensive safety management system. Safety aspects pertaining to rebuilding of Nicoll Highway are presented in this write-up.

Prior to carrying out the above works, the following safety precautions and procedures were adopted:
1) The collapsed area was demarcated into a gridline system so that the work being carried out could be monitored more comprehensively. Before carrying any work, the contractor had to submit method statements that described the nature of the work, the location, the manpower, the machinery to be used, permit-to-work, etc to LTA for approval.

2) The sub-contractor’s supervisors conducted daily toolbox talks for their workers in the presence of a safety supervisor or safety officer.

3) Machinery and crane access routes were planned and constructed prior to any movement and lifting operations. The contractor’s engineer—in-charge had to inspect routes and endorsed the access checklist.

4) Permit-To-Work System
   - The permit-to-work system was reinforced with more stringent measures that required the contractor’s construction manager or senior engineer to submit for approval the relevant permits to LTA. Such permits pertained to “hot work” such as cutting with acetylene torches and arc welding, and all soil investigation, piling and excavation work.
   - No work on site was allowed to commence until after LTA’s engineer had approved the work.

5) LTA site personnel conducted daily “planned general inspections” (PGI) at the collapsed site. In addition, LTA’s deputy project manager and safety officer also conducted weekly PGIs together with the contractor’s project manager and registered safety officer. The contractor had to rectify immediately any identified sub-standard conditions and practices.

Emergency Preparedness

The contractor had to reinforce its emergency preparedness plan that included:

- A tally board system to keep track of persons, including visitors, entering and leaving the work area.
- More regular emergency and evacuation drills to familiarise the workers on the escape routes and assembly area during an emergency.

Conclusion

With the safety measures implemented and daily work sequence properly planned and carried out on site, the affected area of the Nicoll Highway was safely and successfully re-built. It was re-opened for use by the public as planned on 4 December 2004 after seven months of closure.

Technical Information on the Reconstruction

- Total no. of bored piles installed = 56
- Diameter of bored pile = 1m
- Depth of bored pile = 54m to 63.7m
- Slab thickness = 500mm
- Static load test = Passed
- Pile dynamic analysis (PDA) = Passed

Illustration

by Ong Lui Lin
Project Engineer C624
Introduction

The Circle Line Nicoll Highway station and tunnels between Millenia and Boulevard stations will be constructed along a new alignment, bypassing the collapsed area.

Plan of new alignment

The station will now be sited beneath Republic Avenue, approximately 100m south of its original location. The station will have two entrances. The north entrance will be linked via a pedestrian overhead bridge to the Concourse Building and the south entrance will serve the park nearby.

Aerial view of new alignment

New Approach to Design and Construction

A whole new approach to the design and construction of the new alignment will be adopted. It will incorporate many improvements and safety enhancements to better overcome the challenges of carrying out deep excavation and construction in poor ground conditions.

The new alignment will minimise the risk and difficulty of reconstruction in the vicinity of the collapsed area. The new alignment will utilise the bored tunnelling method for the tunnels with a station relocated beneath Republic Avenue to avoid sterilisation of land.

Bored Tunnels

Bored tunnelling is a proven technology, and with proper control, will cause minimum disturbance to the ground.

New Station

The re-sited station will be further from the existing buildings and less deep. The station will still be constructed using the cut-and-cover method. It will incorporate thicker and deeper permanent diaphragm walls of 1.5m thick, and socketed into a hard stratum to limit both ground movement and water drawdown. The thicker walls will have more robust design conforming to permanent structural requirements.

1 - Install diaphragm wall, bored piles, jet grout piles, plunge column;
2 - Excavate to level and cast roof slab;
3 - Excavate to concourse and cast concourse slab;
4 - Excavate to base and cast base slab;

Top-down construction sequence
Top-down Construction

A special feature of the top-down construction method is that the top slab is cast before further excavation to lower levels. This ensures that the retaining walls are supported by permanent structural slab instead of temporary steel struts.

Temporary Work Design

The design for the temporary works will be enhanced as the temporary works will be designed to the same standards as those for permanent works and no over-stress will be allowed. An independent checking engineer will now be employed by LTA to check and endorse the design of the temporary works.

Supervision

A tighter supervision and monitoring regime will also be instituted to strengthen quality control of construction work, including both the project and design teams on site.

Instrumentation

In order to ensure the quality of instrumentation and monitoring, LTA will appoint an independent specialist sub-contractor, reporting directly to LTA, to carry out the instrumentation monitoring work. The data management system and real-time monitoring of strut loads will be enhanced in terms of frequency and accessibility.

Enhanced Ground Improvement Method and Quality Control

The quality control of jet grouting will be stepped up. The operating parameters shall be checked and recorded continuously by an automatic data logger.

A hybrid ground improvement technique, combining mechanically mixing of in-situ soil with cement slurry and jet grouting will be used so that high quality large diameter soil mix columns can be formed below ground.

Conclusion

These improvements and safety enhancements will ensure that the construction along the new alignment will be carried out in the safest and least disruptive manner.

by Foo Siang Jeok
Design Engineer

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Civil Design Department
In May 2005, two Construction (Design and Management) (CDM) consultants from the UK, engaged by LTA, were in Singapore to share their experience of the regulations as practised in the UK. For selected LTA officers, there was a full-day seminar on 17 May 2005, followed by detailed discussions the next day. A full-day seminar was also conducted on 19 May 2005 for more than 200 invited key players from the local construction industry, comprising senior representatives from government agencies, professional institutions and trade associations.

LTA staff at the CDM seminar

Key Objectives of CDM

CDM was legislated in UK in 1994 to improve health and safety management in the UK construction industry together with the Construction (Health Safety and Welfare) Regulations 1996. CDM is intended to encourage the integration of health and safety into project planning and management with the following objectives:

1. Early appointment of competent duty-holders with sufficient resources to fulfil their legal duties through active co-operation to facilitate early identification and reduction of risks;
2. A realistic project programme with adequate time, effort and resources commensurate with the risks and complexity of the project for planning, preparation and execution of the work including managing health and safety issues; and
3. Provision of health and safety information from the start of design, through construction and maintenance to eventual demolition, so that everyone can discharge his/her duties effectively.

Key Duty-holders

(a) Client

The Client sets the tone for a project and makes crucial decisions for the development. CDM places explicit duties on Clients, requiring them to appoint competent people, provide relevant information, and ensure that there are adequate time and resources for each stage of work.

(b) Designer

Duties are also placed on Designers (e.g. architects, consulting engineers, quantity surveyors, specifiers, chartered surveyors) to ensure that health and safety are accorded equal priority along with architectural and engineering standards, buildability, quality, cost and time.

(c) Planning Supervisor

This was a totally new role created in the UK in 1994 to co-ordinate health and safety issues related to design. An individual or a firm with excellent knowledge of the design process, health and safety issues as well as the construction process can perform the role of the Planning Supervisor.

(d) Principal Contractor

The Principal Contractor needs to convince the prospective Client that his company has adequate resources and possesses the competence to carry out the job. Similarly, the Principal Contractor shall ensure that any other designers or contractors engaged by him are also competent and have adequate resources.

Key Documents

(a) Pre-tender Health and Safety Plan

This project-specific document addresses the key health and safety issues, in particular those that tenderers could not reasonably be expected to know. The main objective is to ensure that the tenderer gets the necessary information that can be taken into account when submitting a tender or bid to the Client.

(b) Construction Phase Health and Safety Plan

This project-specific document builds on the information provided in the Pre-Tender Health and Safety Plan. It must set out the health and safety goals for the project and explain how the key health and safety issues will be managed. The following broad categories are listed below:

1. Description of project;
2. Communication and management of the work, e.g. group meetings, toolbox meetings, emergency procedures and drills, control of contractors, risk assessments, method statements;
3. Arrangements for controlling significant health and safety risks on-site; and

(c) Health and Safety File

This is essentially a collation of documents highlighting the impact on health and safety for operation, cleaning, maintenance and eventual demolition that shall be handed over to the end users of the completed facility to inform them of the risks.

Key Issues and Concerns Discussed at the Seminars

Responsibility and Accountability

Much interest was generated on the legal liabilities of the various duty-holders. The questions led directly to the CDM
requirements that require assessment of competency and adequacy of resources:

(a) Competency: suitability of appointed duty-holders such as the Designers, Planning Supervisor and Principal Contractor and Contractors.

(b) Resources: adequate budget for health and safety management included in the contract sum and construction schedule.

Any duty-holder can be held accountable for a design decision made without adequate consideration for health and safety that eventually lead to an accident. In addition, being a member of a professional body (e.g. Chartered Engineer, Professional Engineer) does not automatically qualify the appointed duty-holder as suitable for the job, it must be based on relevant experience and qualifications. A competent person is one who has the appropriate knowledge and/or technical experience to undertake a task. He/she must also know and recognise his/her limitations and work within his/her comfort zone.

Multiple Duty-holders in Same Organisation

An organisation that has the capability of appointing its own Designers, Planning Supervisor and even possibly Principal Contractor can do so, provided there must be a degree of objectivity and autonomy such that clear lines of responsibility and accountability are assigned. In the event of any accident investigation in such an organisation, the authorities will trace up the hierarchical structure in the organisation to determine the party or parties responsible.

Documentation

Regarding the contents of the key documents, the consultants referred the participants to the Approved Code of Practice and Guidance on CDM Regulations 1994 published by the Health and Safety Executive (HSE). The consultants clarified that there is no official approving body for the key documents prepared and that the system is self-regulatory. HSE will randomly select companies to audit and these companies need to justify their compliance with CDM.

Conclusion

After more than 10 years of implementation, the UK CDM Regulations are now put under extensive review with intensive industry-wide consultation. The new CDM Regulations will aim at removing any ambiguity, conflicts and overlaps that CDM may have with the Construction (Health Safety and Welfare) Regulations 1996.

The participants of this seminar representing a full spectrum of the Singapore construction industry had the opportunity to learn from the practitioners in what they must avoid or adhere to should a similar framework be developed here. We must avoid the misconception that CDM Regulations are only meant to generate voluminous paperwork without any tangible contribution to the safety and health management of the industry.

Typical Process for a Building Construction Project Under CDM Regulations

by Tan Hock Seng Andrew
Senior Construction Safety Officer
We accord the highest priority to safety in our construction and project works.

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