13 MAY 2005

PRESS RELEASE

COMMITTEE OF INQUIRY CONCLUDES STRING OF CRITICAL DESIGN ERRORS CAUSED COLLAPSE AT NICOLL HIGHWAY.

The Government today released the final report by the Committee of Inquiry (COI) into the Nicoll Highway collapse. The COI concluded that critical design errors led to the collapse of part of the earth-retaining wall system, which killed four workers. (An executive summary of the Committee's findings and recommendations is at Annex A.)

Cause of the Nicoll Highway Collapse

2 The Committee concluded that the Nicoll Highway collapse was initiated by the failure of the strut-waler support system for the excavation at the nearby MRT Circle Line project C824. On the day of the collapse, several walers buckled, leading to an eventual cave-in of the retaining walls of the excavation site. (Please refer to Annex B for a diagram of the accident site.)

3 The Committee identified the critical design and construction errors that led to the failure of the earth retaining wall system as:

i) Use of an inappropriate soil simulation model which over-estimated the soil strength at the accident site and underestimated the forces on the retaining walls within the excavation;

ii) An error in the design of the strut-waler support system with the connections being under-designed; and

iii) Deviations in actual construction, which further aggravated the under-designed conditions.

The net effect of these errors in 3(ii) and 3(iii) resulted in the strut-waler system being about 50% weaker than it should have been.

4 The Committee also found deficiencies in the project management that perpetuated and aggravated the design errors. The human and systemic failures included:

i) Inadequate instrumentation and monitoring of works;
ii) Improper management of instrumentation data;
iii) Lack of competency of persons carrying out specialised work;
iv) Incapacity of the project management team and supervisory personnel to identify adverse trends in the construction process and implement corrective measures;
v) Problems in the inter- and intra-party chain of command and communication between LTA, NLCJV and the sub-contractors; and
vi) Lack of clarity in the reporting structure for decision-making among the different parties involved in the project.

Lessons and Recommendations

5 The Committee made the following broad recommendations with respect to reforming the safety framework and improving safety for future similar projects:

i) Potential for major accidents must be recognised and addressed through use of hazard identification and risk analysis. This includes ensuring that the design for temporary works is robust, independently checked, and regularly reviewed;

ii) A strict weightage system should form part of the contract and tender evaluation system. The weightage system should include non-technical and non-commercial attributes such as safety records and culture of the bidder, and its core or corporate competency;

iii) There must be a strong safety culture among all at work, including continuous and visible commitment by management and consultation with stakeholders from design to execution;

iv) Organisational and human factors must be taken into account when devising safety management systems, for instance:

- Instrumentation and monitoring must be carefully managed, especially when there is potential for public harm;
- Senior managers must be experienced enough to make the right judgment call either to suspend or stop work;
- Production pressures must be balanced by defensive precautionary systems;
- Professionals and sub-contractors must have the right competencies and training;

v) Major projects in close proximity to the public with the potential to cause significant harm require particular review, and should have comprehensive emergency plans; and

vi) New or unfamiliar technologies must be rigorously understood and assessed before being adopted.

Recommended Prosecution Action

6 The Committee has recommended the Public Prosecutor to inquire into and take cognizance of the following contraventions by these parties:

No	Name/Designation	Offence/s	Possible Penalty
1	Nishimatsu Construction Company Limited (NCC)	Two offences under the Factories Act: - section 33(1)(a) for failing to ensure that the temporary retaining wall system in Project C824 was of sound construction and properly maintained; and - section 33(3) for failing to ensure that the worksite at C824 was safe for persons working there.	Liable on conviction to a fine not exceeding $200,000 for each offence.

No	Name/Designation	Offence/s	Possible Penalty
2	Mr Shun Sugawara Project Director, NCC	An offence under section 33(3) read with section 88(13) of the Factories Act as an officer of the company for facilitating the commission of the offence by NCC by his neglect; ie. for failing to ensure that the worksite at Project C824 was safe for the persons working there.	Liable on conviction to a fine not exceeding $200,000 or to imprisonment for a term not exceeding 12 months or both.
3	Mr Paul Broome Project Co-ordinator, NCC	Two offences under the Factories Act as an officer of the company: - under section 33(1)(a) for facilitating the commission of the offence by NCC by his neglect; ie. for failing to ensure that the temporary retaining wall system in Project C824 was of sound construction and properly maintained; and - under section 33(3) for facilitating the commission of the offence by NCC by his neglect; ie. for failing to ensure that the worksite at Project C824 was safe for the persons working there <u>Alternative charge</u> An offence under section 304A of the Penal Code for causing the death of the 4 persons working in Project C824 by his negligent act.	Liable on conviction to a fine not exceeding $200,000 or to imprisonment for a term not exceeding 12 months or both. Liable on conviction to imprisonment for a term not exceeding 24 months or to a fine or to both.
4	Mr Kazuo Shimada Design Manager, NCC	Two offences under the Factories Act as an officer of the company: - under section 33(1)(a) for facilitating the commission of the offence by NCC by his neglect; ie. for failing to ensure that the temporary retaining wall system in Project C824 was of sound construction and properly maintained; and	Liable on conviction to a fine not exceeding $200,000 or to imprisonment for a term not exceeding 12 months or both.

No	Name/Designation	Offence/s	Possible Penalty
		- under section 33(3) for facilitating the commission of the offence by NCC by his neglect; ie. for failing to ensure that the worksite at Project C824 was safe for the persons working there. <u>Alternative charge</u> An offence under section 304A of the Penal Code for causing the death of the 4 persons working in Project C824 by his rash act.	Liable on conviction to imprisonment for a term not exceeding 24 months or to fine or to both.
5	Mr Ng Seng Yoong Qualified Person, LTA	An offence under section 19(1) of the Building Control Act for breaching condition 8 of the statutory duties in the Conditions of Permit, issued pursuant to section 7(2) of the same and imposed on him as the Qualified Person of Project C824.	Liable on conviction to a fine not exceeding $10,000 or to imprisonment for a term not exceeding 6 months.

7 The Committee has also recommended that a minimum sanction of warning be issued in lieu of prosecution to the following parties for their conduct and/or omissions that contributed to the poor management of Project C824:

No.	Name/Designation
1	Mr Tomio Ueno Deputy Project Director, NCC
2	Mr Ishibashi Atsushi Design Engineer, NCC
3	Mr Arumaithurai Ahilan Assistant Geotechnical Engineer, NCC
4	Ms Shirley Jayanthi Sivakumaran Senior Design Engineer, LTA
5	L & M Geotechnic Pte Ltd
6	Mr Chakkarapani Balasubramani Supervisor, L&M Geotechnic Pte Ltd

7	Monosys (S) Pte Ltd
8	Mr Eugene Tang Project Engineer, Monosys (S) Pte Ltd

8 In addition, the Committee also recommended that the LTA's Director of Projects and Engineer of C824, Mr Rajan Krishnan, the Project Manager, Mr Wong Hong Peng and NCC's safety officer on site, Mr Roslee Bin Sutrisno, be counselled.

9 The Committee's full report is available on the MOM website at www.mom.gov.sg. The Government is reviewing the Committee's recommendations and will give its response soon.

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Annex A

THE FINAL REPORT FROM THE COMMITTEE OF INQUIRY INTO THE NICOLL HIGHWAY COLLAPSE – EXECUTIVE SUMMARY

THE CAUSE AND CONTRIBUTORY CAUSES

The 20 April 2004 Nicoll Highway collapse in the C824 project was rooted in history.

It began with two critical design errors. These were the under-design of the diaphragm wall using Method A and the under-design of the waler connection in the strutting system. These design errors resulted, in the event, in the failure of the 9th level strut-waler connections together with the inability of the overall temporary retaining wall system to resist the redistributed loads as the 9th level strutting failed. The catastrophic collapse then ensued.

The collapse did not develop suddenly. A chain of events preceded the collapse.

Several technical and administrative factors contributed to the collapse. From the early stages of the C824 project through to final collapse, there were failures to demonstrate the necessary level of care. Serious human errors were made. Warnings of the approaching collapse were present from an early stage but these were not taken seriously. The builder did not adequately deal with insidious warning signs. A multiplicity of events led to the position where design, construction, instrumentation, management and organisational systems used by the builder and their sub-builders failed. There were failures in the defensive systems. There were no proper and appropriate design reviews. There were inadequate contingency and remedial measures.

Two significant contributory factors are the abuse of the back analyses in Type M3 where the collapse took place and the failure to institute a regular, close and effective monitoring regime. The two critical back analyses at Type M3 were geotechnically flawed. There were repeated breaches of the instrumentation review levels at Type M3. All the experts agreed that on the basis of the second back analysis for Type M3, work should not have been allowed to proceed in that area.

The catastrophic collapse was the finale to mounting incidences and warnings in the C824 project of excessive wall deflections, surging inclinometer readings, waler beam buckling, stiffener plates buckling, ground settlement, trespass of water and soils into the excavation through cracks in the diaphragm walls, failure of concrete corbels, wailing waler beams, falling support brackets, plunging strain gauge readings, and the ‘thung’ sounds of distress over 6 hours on 20 April 2004 from the heart of the strutting system.

Time took its toll. 3.30 pm, 20 April 2004 – the Nicoll Highway collapsed.

The collapse falls squarely on the builder, Nishimatsu-Lum Chang Joint Venture.

The Nicoll Highway collapse could have been prevented.

OTHER FINDINGS

Many other findings have been made by the COI in the course of the Inquiry. Essentially these relate to the need for a robust design, a risk based approach to design and management, a purposeful back analysis, an effective instrumentation, monitoring and interpretation regime, quality during construction, corporate competencies of contractors and safety management. The tender process was also considered.

In summary, these findings are:

(1) The inclinometers at key locations of the diaphragm wall were not monitored daily during critical periods. The opportunity to detect adverse trends was lost.

(2) The interpretation of the instrumentation data was perfunctory.

(3) Reliance on past experience was misplaced and not properly adapted to other localised incidences in the project. 'Standard' but undifferentiated remedial measures were ineffectual.

(4) The management of uncertainties was deficient.

(5) There were many unsafe acts. Safety risks were not respected. The safety culture in the entire project was remiss.

(6) Contingency plans and emergency procedures required to deal with adverse events on site were inadequate.

(7) The overall corporate competency of the builder was insufficient.

SAFETY

Safety and safety culture in the C824 project fell short.

The need for safety stood out in the Inquiry. One clear lesson is a continuing need for the public authorities, owners and builders in deep excavation works to engender public confidence in the safety of their projects.[1] The COI has therefore devoted an entire Chapter 7 in this Report to Safety. The Report sets out the principal safety errors and organisational failures in the C824 project. The real question is not what safety costs us, but what it saves. The COI has drawn several lessons and made recommendations which are intended to improve the safety management and processes in deep excavation works in Singapore. These are set out below.

There were many safety mistakes and errors from March 2003 up to and including the day of the collapse, 20 April 2004. There was a history of safety errors and organisational failures. Such organisational failures are the manifestation of a lack of safety culture in the execution of the C824 project. Organisational accidents are rare but often catastrophic events as evident in this Inquiry. There were undoubtedly

[1] See statement by the Minister for Transport, Mr Yeo Cheow Tong, at the 30th International Tunnelling Association General Assembly on 24 May 2004.

human errors but these were merely a consequence of foreseeable organisational failures.

The incident of the Nicoll Highway collapse was rooted, among others, in failures in defensive systems that did not adequately deal with hazard identification, risk avoidance and reduction and the control of remaining residual risks. The lack of safety sensitivity and culture of the builder and their sub-contractors was manifested with dire consequences on the day of the collapse, 20 April 2004.

A critical safety failure was that no stop work order was issued in the face of unsafe acts, unsafe conditions and unsafe attitudes. A stop work order is an essential and crucial element that must exist as a viable safety measure in the construction process. Stop work order must be an exercisable and realistic option.

The site problems from March 2003 to April 2004 showed a lack of an informed safety culture.

The other safety mistakes are:

(1) Safety errors in instrumentation and monitoring;
(2) Lack of clarity in the chain of command and ineffective communication, and
(3) Safety errors in the back analyses at Type M3.

The principal recommendations on safety are set out in Chapters 7 and 8 of the Report. These recommendations took into account the views of the Ministries of Manpower, National Development and Transport, and stakeholders in the construction industry as well as the NTUC and SCDF. They rightly demonstrate intolerance of safety errors and the need for a strong safety culture.

In summary, the main safety lessons and recommendations (which include the COI's Interim Report and the Government's Response to the COI's Interim Report) are as follows:

(1) Temporary works were not given the same respect as permanent works. The Government, in its Response to the COI's Interim Report, agreed that the structural safety of temporary works is as important as that of permanent works and should be designed according to established codes and checked by competent persons.

(2) In addition, in deep excavation works, it is useful to evaluate the project on the basis of its risk profile.

(3) There must be a strong safety and safety culture in all construction projects. The Government's Response to the COI's Interim Report agreed that safety systems and a pervasive culture of safety consciousness that permeates every level from developers down to least skilled worker must be in place. In this regard, the Ministry of Manpower will be introducing the Workplace Safety and Health Act to address safety and health issues through the life-cycle of a building including the design, construction and even maintenance of the building. The implementation of the proposed legislation would augment the

safety management systems and enhance the overall management of safety and health in the construction worksites.

(4) Safety policies must be clear and unambiguous. As disclosed in the Government's Response to the COI's Interim Report, MOM had conducted inspection of the deep excavation sites under LTA. MOM's inspections revealed that while emergency evacuation plans were established and drills conducted by site personnel, clear guidelines on what type of situations call for an immediate evacuation from the worksite had not been established. MOM has addressed this. LTA has also taken the initiative to require its contractors to provide better access and evacuation facilities at a number of sites.

(5) There must be an effective safety management system to minimise risk to employees and others. Such a system should collect, intelligently and reasonably analyse, and disseminate information from incidents and near-misses. In such a safety management system there is a need to consider human factors, including the culture, attitude and belief within the contracting organisation. Safety culture must be concerned with individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to and the style and proficiency of an organisation's approach to health and safety. Those managing the safety process must understand how human failure happens, what can be done to prevent it, how it can be detected and corrected and how to recover.

(6) An effective safety management system must recognise two kinds of accidents: those that happen to individuals and those that happen to organisations. Contracting organisations must then have defensive systems that adequately deal with hazard identification, risk avoidance and reduction, and the control of remaining residual risk.

(7) Safety measures need to be continuously watched, worried about, tuned and adjusted. The cultural mindset must focus on particular risks relative to apparent economies and the need to meet construction schedules.

(8) There is a need to guard against an overly simplistic analysis of incidents and blame only operators. High level errors can play a major part in creating the circumstances where others make errors at the workplace.

(9) Instrument based performance monitoring system must be effective, adequately resourced and maintained. There is a need to integrate information from the various instruments and to relate the crucial information to what is happening on the worksite, as well as the quality of each of the elements in the construction. Management system and resources must be capable of collecting, inputting, processing and interpreting the large amount of instrumentation data.

We note from the Government's Response to the COI's Interim Report that the LTA has re-examined its project management and process and has set up

a risk register[2] for all sites, covering safety, design and construction matters. Site staff are now required to immediately report instrumentation readings which are above the trigger values to a committee comprising senior and project staff for review and follow-up action.

We also note that LTA will also directly handle the appointment of specialist instrumentation contractors for its projects, instead of leaving this to the contractor, so as to have better control over the overall process and the monitoring of construction works. LTA has also instituted quality control of the instrumentation sub-contractors for its on-going projects. This requires contractors to have a quality plan in relation to their scope of works, manpower qualifications, training, as well as instruments and calibration.

(10) Unsatisfactory trends must not only be identified sufficiently early, but doggedly monitored and the subsequent risks appreciated to enable corrective steps to be taken. A regular supply of accurate and up-to-date monitoring information is essential. Its correct and timely interpretation, including comparisons between predicted and actual design values and the trend line from the history of the movements of the temporary walls, is critical to safety.

(11) The chain of command within the contracting organisation must be well established and communication must be effective. There must be ownership of problems, exercise of sound and timely engineering judgment towards the resolution of problems. Only then will such engineering judgment be effectively carried out. There must be a proper chain of command and reporting structure to facilitate the proper flow of information from the site. The Government, in its Response to the COI's Interim Report, agreed that there should be greater clarity in the working relationships between the various project parties in complex projects; and that MND/BCA will look into the issue together with MOM.

(12) The integrity of a back analysis is critical to safety, and is dependent on the basic assumptions that it would be done properly, honestly and in good faith. As soon as the back analysis departs from its basic objective of safety assessment and degenerates into a curve fitting exercise for the purpose of justifying the continuation of work, it would have been transformed from a benign tool to a treacherous contrivance.

(13) The independence of the QP (ST) is essential to avoid situations of conflict of interest so that building works can be constructed with proper and impartial supervision. In this regard, it would be advisable for the LTA to consider appointing an independent QP (ST) from outside the organisation. There is also a need for the LTA to review its current practice of dual appointments to identify potential areas of conflict of interest and to take such measures as to

[2] Risk Registers are 'live' documents that are continually reviewed and revised as appropriate and available for scrutiny at any time. They identify hazards, consequent risks, mitigation and contingency measures, proposed actions and responsibility, and provide an auditable trail through the life of a project to demonstrate compliance.

avoid or reduce the conflict. The practice of appointing the same person as the Project Director and the QP (ST) for the same project, as happened in C824, should be strongly discouraged.

We note from the Government's Response to the COI's Interim Report that the LTA is engaging independent consultant engineers to carry out checks on the design of temporary works for all their projects. BCA is also exploring various options to strengthen the regulatory framework for temporary works pertaining to deep excavation.

(14) The QP (ST) must have sufficient time to carry out his checks seriously and thoroughly. The criticality of the role of the QP (ST) must be recognised and implemented. The check-and-balance role of the QP (ST) must not be forsaken for cost consideration and reduced to a mere perfunctory function.

(15) The COI reiterates the three principles[3] to ingrain safety awareness which have been announced by the Minister for Manpower. These are:

- To reduce risk at source by requiring all stakeholders to minimise or eliminate risks which they create. This requires assessment to identify the source of risks at the work place, the action to reduce these risks and the parties responsible for doing so.

- Industry itself must be required to take greater ownership of safety outcomes. They must self regulate to reduce the loss of lives and injuries to workers under their charge.

- Enhanced criminal sanctions for poor safety management and greater financial disincentives and penalties for workplaces with unsafe systems.

(16) Good ethical practices and high moral standards should prevail over commercial interests. Accordingly, architects, engineers and contractors must perform their professional and contractual duties with due care and diligence with prime regard to safety.[4]

(17) The safety training and educational framework should be reviewed[5] to equip management and workers with relevant information and knowledge of work hazards and safe work practices, particularly in specialised works.

(18) Workers should be empowered to 'whistle blow' on unsafe workplace practices, as well as remove or eliminate work hazards.

(19) Safety should be incorporated as a Key Performance Indicator ('KPI') in both management and workers' performance assessment and reward.

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[3] Statement by the Minister for Manpower, Dr Ng Eng Hen, on A New Occupation Safety and Health Framework in a Ministerial Statement on 10 March 2005.

[4] Statement by the Minister for National Development, Mr Mah Bow Tan, in Parliament on 19 May 2004.

[5] See recommendation dated 20 April 2005 by Mr Yeo Guat Kwang, Director of Quality Worklife, NTUC.

(20) It is essential that we get enough of our local workers, particularly in deep excavation works, to develop core skills. These workers can then be supplemented with foreign workers.

Other safety lessons and recommendations are also set out below.

OVERALL LESSONS, RECOMMENDATIONS AND OBSERVATIONS

Several salutary lessons arise. These lessons and recommendations are set out in this Report in a non prescriptive manner. The underlying principles are: avoidance of hazards and minimising risks and to protect the health and safety of two broad groups of people – those working in a construction site and others who may be affected by the construction activities. Specific recommendations and observations have also been made. These are to ensure that further disasters can be avoided in the construction industry, particularly in deep excavation projects. They would help assure that such an incident does not recur.

Some of the lessons, recommendations and observations made in this Report may over provide on a project to project basis. Each project must be appropriately assessed in considering these views.

In summary, the main recommendations are:

(1) Effective risk management

- Major accident hazards can happen in events that have a low probability of occurring. But when they do, they have considerable consequences for those affected. The Nicoll Highway collapse is one such incident. Such accident must be prevented through effective risk management. This must depend to a considerable extent on management and operators performing their functions of monitoring any risk to ensure day-to-day compliance with the assumptions of the risk assessment. To use the words of the Minister for Manpower, "simply put, those who create the risk will be held responsible to reduce it." The potential for major accidents whether due to the construction process or deficiencies in design, as was seen in this Inquiry, must be recognised and expeditiously controlled. The duty holder must ensure health, safety and welfare at work.

- It is inappropriate to leave the control of risk wholly to contractors. In terms of practical risk management, this duty means reducing risk to a level which is as low as is reasonably practicable. This is essentially a technical issue. It cannot be determined by the contract value of the project.

- Risk assessment should also consider major hazard events which could affect the public and not simply risks to individuals at work. Identified risks can be communicated to others by preparing and making available the risk register referred to earlier.

- The owner, builder and operators must honour and respect their own risk analysis, assessment and reports.

- It should be recognised that human error is not confined to operators. Human errors occur throughout an organisation. High level errors like design, back analysis, use of C-channel and interpretation of monitoring data, can and do play a major part, in the C824 project, in creating the circumstances where others make errors at the work face.

- The absence of a minimum standard of corporate competency was a significant contributor to the things that went wrong in the C824 project. Appropriate competencies must be developed in similar excavation projects.

- New or unfamiliar technologies requires particular review, as do major projects with the potential to cause significant harm to workers or the public.

(2) Managing Uncertainties and Quality

- There is a need for a high quality management which recognizes the presence of uncertainties and fosters a generative culture where responsibilities are shared, mistakes are quickly learned and conflicts are well managed. Roles and responsibilities must be clearly established.

- Owner's and builder's management must seek a balance between production pressures and quality and safety goals.

- There must be honest and regular consultations between the owner and the builder, the QP (ST) and the PE, and the owner's and the builder's designers. This should provide an opportunity for cross-checking and understanding the respective roles and responsibilities of the parties in the defensive system to prevent accidents.

- An effective management is one which demonstrates the effective commitment from the senior management level and involves everyone at work including their safety representatives. Key decisions must be made at the right level and at the right time.

(3) Managing and Monitoring of Geotechnical instrumentation and data

- Monitoring is vital to deep excavation works. There should be appropriate instruments deployed. There should be proper use and management of the collated data. The monitoring system must determine the qualitative and the quantitative data sufficient to meet all design and construction needs. In particular, monitoring during construction must be meticulously undertaken with an eye to safety.

- The COI accepts the recommendations proposed by MOM and the experts in respect of geotechnical instrumentation and monitoring. These are set out in the Report.

(4) Robustness of Design

- A robust design is essential. This robustness is provided by identifying the hazards and risks and checking that the proposed design can adequately withstand them. The design should also have sufficient redundancy to prevent a catastrophic collapse in the event of a failure of any particular element.

- The design must have built-in factors to cater for material deficiencies and construction imperfections.

(5) Design Review and Independent Check

- A design review must be carried out where there is structural distress or when readings from instrumentation readings show deviation or aberrations. This requires a planned programme at the inception of the project.

- Independent checks should be undertaken in all temporary works for deep excavation as is the current practice for permanent works. This is simply because structural safety of temporary works is as important as that of permanent works and should be designed according to established codes and checked by competent persons.

(6) Numerical modelling in Geotechnical Design

- Generally, numerical analysis or modelling should not be over relied. It can only be used to supplement and not supplant sound engineering practice and judgment.

- It must be well undertaken by competent persons. Those who perform geotechnical numerical analysis must have a fundamental knowledge of soil mechanics principles and a clear understanding of numerical modelling and its limitations.

Some primary prescriptive recommendations are in respect of the following:

(1) Jet Grout Piling (JGP)

- There must be a rigorous review to secure a rational understanding of the behaviour of JGP with respect to its function in the designed structure, its mass properties and the need to have a high standard of quality control in its construction.

- Those who are involved in the design and construction of JGP must avail themselves to the body of knowledge such as in learned journals, codes of practice, published guides and other known experience.

(2) Design Guidance and Specifications

- Relevant Codes for deep excavation and strutting system should be developed. Specifications to improve the performance of the design and construction process should be specific.

(3) Emergency Preparedness

- Worksites should develop a contingency plan to address all safety and work related emergencies. The plan should address the various scenarios that could occur and spell out the measures to evacuate all affected workers. The plan must be communicated to and understood by all staff.

- Some of the essential features of any emergency plan have been specifically set out in the Report.

(4) Competencies of Professionals, Contractors and Sub-contractors

- The COI's Interim Report had highlighted the need for personnel engaged in specialist functions to have the minimum knowledge, qualification and experience. Further, as part of their professionalism, specialist sub-contractors must go beyond mere contractual compliance and alert the employer of any deficiency in design, drawing and methods of construction which impacts safety.

- It is a significant step that the Government has taken, in its Response to the COI's Interim Report, that:

  "there should be a minimum standard for sub-contracting works, especially for specialized construction works. BCA will study ways to raise the standard of professionalism of specialist contractors so that only those with requisite skills and expertise are allowed to undertake specialized construction work such as deep excavation."

(5) Contract and Tender Evaluation Process

- There should be separate considerations of commercial and technical aspects. The evaluation of the tender must be done qualitatively through a strict weightage system, besides being done quantitatively. Numerical scores can be assigned, weighted and aggregated. The technical review should cover a range of issues, including health, safety and risks. The weightage system should include non-technical and non-commercial attributes such as the safety record and culture of the tenderer, its safety auditing capacity and its core or corporate competencies. This is along similar lines as the 'price quality method'.

Such a weightage system should apply even if the tenderer is a joint venture as in this case, or a consortium. There may well be uneven safety and performance records among the parties of the joint venture or consortium. A practical approach need necessarily be taken. However, the total safety of the project must be an override.

- At the time of the preparation of this Report, the COI was informed of another major Government commitment. This is the taking of holistic measures to improve safety in high risk sectors such as the construction industry. Dr Ng Eng Hen, the Minister for Manpower announced at the Inaugural National Occupational Safety & Health (OSH) Week on 28 April 2005 that;

  "The public sector which accounted for almost half of the construction demand (or $4.6 billion) in Singapore in 2004 would, in future, attach a premium to safety in the procurement process. Public sector agencies would also ***offer incentives for good safety performance of the successful tenderer****."* [emphasis added].

Other Recommendations

In addition to the above summary, wide ranging recommendations have been made by the various experts engaged by the parties, the stakeholders in the construction industry as well as the NTUC, the Straits Times, Lianhe Zaobao and the Berita Harian. The COI's other recommendations in its Interim Report continue to be valid. All these are elaborated and detailed in the Report.

Salutary Lessons

All told, the salutary lessons are broadly as follows:

(1) A design review when carried out must be based on sound engineering basis and judgment.

(2) Stop work order must be an exercisable and realistic option.

(3) An effective framework of hazard identification, consequence analysis, risk reduction strategies and a responsive safety management should be implemented to identify and address any potential human errors and systems that may cause or contribute to a major accident.

(4) A major deep excavation project which has the potential to cause harm and inconvenience to the public must be specially managed with careful instrumentation and monitoring.

(5) There must be a continuous and demonstrable commitment by management, and workers, accompanied with a frank and honest consultative approach, to ensuring safety and health, from inception of design to execution of the project.

(6) An effective management system particularly in a deep excavation project is critical. Such a system must be responsive to organisational and human factors in the execution of the project, and must secure health and safety.

(7) New or unfamiliar technologies, when applied to deep excavation works, must be thoroughly evaluated and their limitations understood before they are adopted.

(8) Production pressures must be balanced by defensive precautionary systems.

CRIMINAL LIABILITY

The Committee has carefully examined the conduct of every person and party involved in the C824 project. The Committee recognizes that there can be a spectrum of culpability or range of blameworthiness by those who failed in the discharge of their duties. This can range from deliberate action, reckless indifference, oblivious carelessness, and poor attitude to safety.

Ends of justice and public interests are never achieved by the mindless pursuit of every single transgression of the law, but always tampered by a fair and even-handed consideration of all relevant factors. The circumstance of each case must be determined in considering whether criminal prosecution is appropriate or whether a lesser sanction would suffice. While there is no doubt that those at the higher end of culpability should be dealt with firmly and severely in accordance with the full sanctions of the law, there will be those at the lower end of the spectrum where criminal prosecution may not be warranted.

The Report recommends a graduated scale of culpability, from criminal prosecutions to warnings and counselling.

On the evidence at the Inquiry, Nishimatsu Construction Company, Ltd ("the company") has contravened sections 33(1)(a) and 33(3) of the Factories Act, Cap 104. It did not provide a place of work, in executing the C824 project, which was of sound construction and properly maintained. It failed to take all reasonably practicable steps to make and keep the construction site safe.

Two officers of the company are also liable under section 88(13) of the Factories Act or in the alternative section 304A of the Penal Code, Cap 224.

The LTA's QP (ST) is in breach of condition 8 of the permit to carry out building works and therefore liable under section 19(1) of the Building Control Act, Cap 29.

Two senior employees, and an assistant engineer from the company, a senior engineer from LTA, a supervisor and an engineer from two sub-contractors as well as 2 sub-contracting companies are to be warned for *prima facie* contravention of section 81 of the Factories Act, section 88(13) of the Factories Act or section 336 of the Penal Code as the case may be.

The LTA "Engineer" for the C824 contract, the LTA Project Manager and the company's registered safety officer on site are to be counselled by the Ministry of

Manpower for their poor attitude to safety in respect of the C824 project. There is no *prima facie* evidence of any criminal offence against them.

Bearing in mind that the stop work order is an essential and critical element that exists as a safety measure in the construction process, the failure to stop work is clearly a failing of the entire LTA C824 team for which the LTA "Engineer", as the most senior LTA officer having overall control of the project, is primarily accountable.

The LTA Project Manager's attitude towards safety in the execution of the C824 project was unacceptable.

The registered safety officer did not adopt a proactive approach towards safety.

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Annex B

BACKGROUND AND DIAGRAM OF THE ACCIDENT SITE

The registered occupier of the Nicoll Highway worksite is Nishimatsu Construction Company Limited (NCC). The "cut and cover" method was chosen to construct the underground tunnels between the Nicoll Highway and Boulevard stations. With this method, a large cavity, with retaining concrete walls, is progressively excavated from ground level to tunnel depth, which in this case was 33 metres. As the cavity gets deeper, the retaining walls are braced with a strut-waler support system**.** This system comprises steel bars (struts) which are connected to bars running parallel to the walls (walers). The purpose of the walers is to distribute the forces exerted by the struts along a larger surface area of wall. When work is completed within the cavity, it is filled back with soil.

At about 3.30pm on 20 April 2004, a collapse occurred at part of the excavation site known as "Type M3", which was directly adjacent to the Nicoll Highway. At the time of collapse the cavity had reached about 30 metres in depth.