EDITORIAL PAGE

Annual Safety Award Convention (ASAC) 2012

ASAC gives recognition to LTA's contractors who have been most proactive and successful in safety, health and environment efforts. In addition to the prestigious awards that will be presented, this year's event will feature the launch of the Zero Accident movement and the Construction Safety Guidebook. Do keep a lookout for the highlights of the event in the next issue of Safety News.

LTA 27th Safety Workshop

The 27th Safety Workshop organised by Safety Division was held on 16th May 2012 at the HSO Auditorium. It was attended by more than 100 officers from Rail, Road Projects and Engineering Groups. The forum served as an excellent platform for project teams to share the safety challenges they faced and how they were overcome. Topics presented were:

1. Changes in Earth Control Measures (ECM) Requirements and Case Studies on LTA Construction Sites by Mr Goh Wee Kiat from Catchment & Waterways Department, Public Utilities Board (PUB).
2. Bukit Timah Canal Localized Diversion – Installation of 2.6m Diameter Twin Steel Pipes (C916) by Executive Project Engineer Michael Tom
3. Half-Height Platform Screen Doors (HHPSD) Installation At Existing 36 Elevated Stations (C1320) by Principal Engineering Officer Teo Kim Yon

Guest Speaker
Mr Goh Wee Kiat
from PUB

Executive Project Engineer
Michael Tom

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or scan

Land Transport Authority

Safety News

Safe Use of Heavy Machinery at Work

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Featured Articles

SAFE USE OF HEAVY MACHINERY AT WORK

Introduction

With the increase in both infrastructure and building construction in recent years, many kinds of heavy machinery have been developed to increase the efficiency and safety of construction work. Such heavy machinery used on construction sites typically consist of bored piling rigs, cranes and excavators.

The use of heavy machinery, while increasing the efficiency of construction work, carries the inherent risk of causing serious injuries and property damage if it is involved in an accident. This article aims to identify common causes of accidents related to heavy machinery and how the associated risks can be minimized or eliminated through the use of the 3Ms (Man, Machinery and Methods) approach.

Causes of Heavy Machinery Accidents

There are numerous and various causes of machinery related accidents that can be broadly categorized into:

Planning & Supervision
- Insufficient procedures / resources
- Failure to adhere to procedures
- Lack of supervision

Equipment
- Lack of maintenance regime
- Faulty / illegally modified components

Human Factor
- Negligence
- Inexperience
- Complacency
- Poor communication

Hence, using the 3Ms approach to manage and mitigate these risks would ensure that working with heavy machinery would be made much safer.

Man

Training
All personnel involved in the operation of heavy machinery must attend and pass the relevant training courses. Besides passing the prescribed courses, it is also important to ensure that the personnel are always reminded of the potential hazards that the machinery they are operating can pose.

Competent / Appointed
The relevant personnel associated with the heavy machinery must be deemed competent and formally appointed prior to operation of the machines.


Figure 1: Appointed competent banksman


Figure 2: Appointed lifting team

Planning
Comprehensive planning and coordination among the various construction teams are essential to ensure that all parties involved in the use of the heavy machinery or working nearby are well aware of the hazards and the measures that can be implemented to mitigate these hazards.


Figure 3: Planning and coordination meetings

Supervision
During the operation of heavy machinery, close supervision must be conducted to ensure that the work is carried out in a safe manner and within a safe environment. Special attention and supervision has to be dedicated to heavy machinery operations that are carried out late in the night and during early morning where fatigue may set in, resulting in loss of concentration. We must also step up supervision during weekends and public holidays when project management staff tend to be fewer.


Figure 4: All lifting works are closely supervised

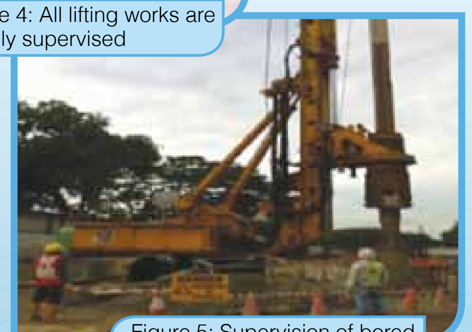
Figure 5: Supervision of bored piling operation

Machinery

Examination
Heavy machinery such as cranes and bored piling rigs which involve lifting operations have to be examined, load tested and certified by an Authorised Examiner prior to usage on site.

For excavators, it must be examined and certified by the supplier's mechanic before commencement of work.

Classification	Frequency of Certification
Lifting Machine	6 months

Classification	Frequency of Maintenance
All Machinery	1 month

Source: LTA General Specification

Maintenance Regime
All machinery will have to undergo monthly maintenance by the Crane Maintenance Supervisor or the main contractor's mechanic. All records of the maintenance are to be kept for verification purposes.

Crane, excavator and bored pile rig operators are also required to perform daily pre-operation checks on the machinery that they are operating.

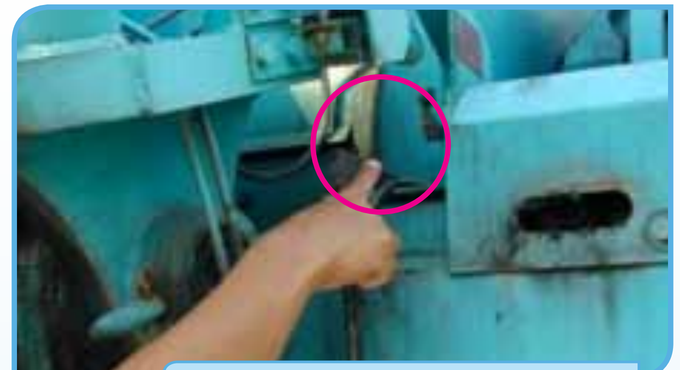
Figure 6: Inspection: over-derricking limit switch


Figure 7: Excavator operator conducting pre-operation checks

Methods

Use of heavy machinery should be properly planned and safe procedures should be developed before the actual operation.

Risk assessment
Detailed risk assessment must be carried out before heavy machinery operations as it identifies the associated safety and health hazards and the level of risks involved. Measures to reduce the risks identified must also be implemented.


Figure 8: Conducting risk assessment

Safe Work Procedure
Safe work procedure must be developed and cascaded to all personnel involved for the purpose of carrying out work safely.

Permit-to-Work
Permit-to-Work (PTW) is a system to manage and control hazardous work and shall be implemented for heavy machinery operations. The contractor's supervisor coordinating the heavy machinery operation is to apply for the PTW to carry out the operation. In the application for PTW, he should state the scope and conditions in which the operation is to be carried out. An independent inspection by an assessor is then conducted on-site to verify that appropriate control measures have been taken to mitigate any foreseeable risks. After confirming that the measures have been implemented, the application would then be approved by an authorized person (typically the project manager).

Control of work area
Access to the working area should be restricted to those who are involved in the work. The work area should be cordoned off, warning signs are to be displayed and steel plates are to be provided at the base of machines for firm footing.


Figure 9: Work area cordoned off

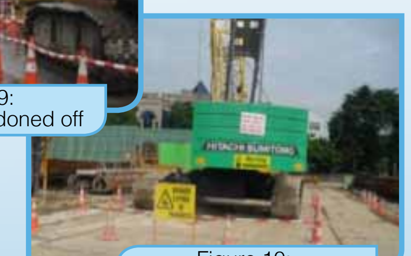
Figure 10: Demarcated work area

Conclusion

As all heavy machinery related operations have an inherent degree of risk, proper risk management is important to identify the potential hazards and address them. These risks can be significantly minimized or eliminated through the 3Ms approach.

It is of paramount importance to ensure all heavy machinery operations on LTA sites are carried out safely. With close collaboration between our project teams and contractors, we can achieve this goal.

Kok Chun Chiat Alvin
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Safety Division

PREVENTION OF COMPRESSED AIR ILLNESS AND BAROTRAUMA

Introduction

Tunnel boring machines (TBM), also fondly known as "moles", are machines used to excavate circular tunnels through various types of soil conditions. They are ideal for use in heavily urbanised Singapore for the construction of our underground rail network as it has the advantage of causing minimal disturbance to the surrounding ground and its ability to tunnel deep beneath the ground surface.

LTA tunnelling works can reach depths of 57 meters. At such depths, compressed air must applied at the cutter-head chamber of the TBM (area behind the cutter-head) to stabilize the tunnel face against soil collapse so that site personnel can enter safely to carry out works such as inspection, change of cutting tools, removing of underground obstruction etc.

Figure 1: Tunnel Boring Machine

Entry & Exit From Compressed Air Environment

In order for personnel to transit safely from a free-air environment to a compressed air environment, a chamber within the TBM, called the man-lock is used.

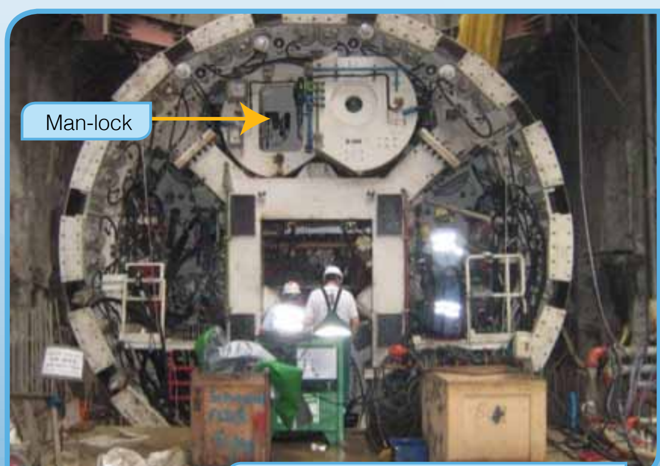

Figure 2: Man-lock located in a TBM

Personnel working in a compressed air environment must first enter the man-lock where air pressure is gradually raised to the desired level (compression) for them to carry out work in the cutter-head chamber. After the work is completed, they will have to return to the man-lock to decompress allowing their bodies to normalise to the free-air atmospheric pressure.

Personnel who enter and/or work in a compressed air environment are exposed to health hazards such as decompression sickness and barotrauma if the process is not well managed.

Decompression Sickness & Barotrauma

Decompression Sickness
At normal atmospheric pressure, the body tissues and blood are fully saturated with air. When the body is subjected to increased air pressure, more of the gases in the air (mainly nitrogen and oxygen) get dissolved into the blood and tissues. When the ambient air pressure is reduced too fast during decompression, these gases are released in the form of bubbles. The oxygen can be utilised by the body through blood circulation. However, the nitrogen gas bubbles formed in the blood stream caused obstruction to blood flow giving rise to the symptoms of decompression sickness. There are 2 types of decompression sicknesses.

Type I Decompression Sickness
Pain in the joints, muscles or limbs may develop soon after working in an hour or even later. The pain can be mild to severe.

Type II Decompression Sickness
Occasionally, workers may suffer from a more serious type of compressed air illness affecting the nervous system, lungs or the heart. Workers usually feel and appear ill. The onset can be during decompression, soon after (usually within 45 minutes) or up to 24 hours later. A worker may develop both Type I and Type II symptoms from the same decompression.

Treatment
All decompression sickness must be treated by a doctor who is trained in compressed air work and recompression with oxygen breathing in a medical-lock.

Figure 3: Medical Lock Chamber

Barotrauma
Barotrauma is the physical damage to body tissues caused by a difference in pressure between the air space inside the body and the surrounding atmosphere and typically occurs when the body moves to or from a higher pressure environment.

Damage occurs in the tissues around the body's air spaces because gases are compressible and the tissues are not. During increases in ambient pressure, the internal air space provides the surrounding tissues with little support to resist the higher external pressure. During decreases in ambient pressure, the higher pressure of the gas inside the air spaces causes damage to the surrounding tissues if that gas becomes trapped. Common symptoms include burst eardrums and bleeding around the eyes.

Prevention Of Decompression Sickness & Barotrauma

Besides conducting a thorough risk assessment to identify, assess and control the hazards, having a robust system to manage work in compressed air is essential in preventing decompression sickness and barotrauma cases. The compressed air work management system should also include:

1. A medical fitness and surveillance program that ensures personnel working in a compressed air environment first undergo a medical fitness examination and certified medically fit by an appointed designated workplace doctor. Thereafter, the medical examinations must be carried out at prescribed frequency throughout the course of the compressed air work.

2. A procedure for personnel to declare and report their health status to their supervisors if they have a cold, sore throat, ear-ache or chest infection which would render them unfit for compressed air work. Personnel with the above mentioned symptoms must not be allowed to continue working in a compressed air environment as it would increase their risk of barotrauma.

3. Trained and qualified man-lock attendants to carry out all compression and decompression procedures.

4. A procedure to identify new personnel so that they can be trained and instructed on the precautions to be taken while working in a compressed air environment. New personnel must also be accompanied by experienced personnel as well as given time to acclimatise to a compressed air environment.

5. A monitoring system to ensure that personnel who work in compressed air environment shall spend at least 12 consecutive hours at normal atmospheric pressure in any 24 hour period.

It is important to note that no personnel shall be required or permitted to be employed in a compressed air environment at a pressure more than 3.5 bar unless with prior written permission from the Commissioner for Workplace Safety and Health.

Safety Precautions When Working In A Compressed Air Environment

The following are some precaution that you can follow to prevent decompression sickness and barotrauma if you work in a compressed air environment:

During Compression
i. Breathe normally and follow the instructions of the man-look attendant. Pinch your nose and try breathing out. You should fell air leaving your ears (this is also known as the Valsalva manoeuvre); and

ii. Should there be any discomfort or pain experienced, inform the man-lock attendant.

During Decompression
i. Breathe normally; do not hold your breath. Wait patiently for the man-lock attendant's signal before attempting to exit the man-lock; and

ii. Change your position frequently to improve blood circulation. Straighten your arms and legs as far as possible and inform the lock attendant if you develop pain, discomfort or dizziness.

After decompression
i. Remain on the worksite for at least an hour if you have been working in a compressed air environment with pressure of one bar or more, this is to look out for symptoms of decompression sickness;

ii. Do not take too hot or too cold a bath/shower. In addition, do not fly, dive or engage in strenuous exercises (like jogging or swimming) for at least 24 hours; and

iii. Have adequate rest in between shifts and drink plenty of water to prevent dehydration.

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Work Safety with Heavy Machinery for CTE Widening Project

Introduction

The Central Expressway (CTE) has served Singapore well since 1991, serving as a vital road link between the city and the North and Northeast regions of Singapore. Currently, it is heavily utilized as it provides access to towns such as Ang Mo Kio, Hougang, Sengkang, Yishun, Sembawang and Woodlands. Today, CTE is operating at full capacity and traffic demand is expected to increase as these towns develop further in the next 10 to 15 years. As such, CTE was widened to help alleviate the current traffic congestion and to meet the anticipated increase in traffic demand.

With the completion of CTE widening project in 2012, motorists now benefit from 4 continuous lanes along CTE and seamless travelling with 2 new flyovers. The widening of CTE involved the successful launching of 218 prestressed precast (PSPC) beams, with the heaviest beam weighing 170 tonnes and longest beam checking in at 45m.

This article aims to focus on the various safety processes involved while working with mobile cranes for PSPC beam launching operations.

Use of Prestressed Precast (PSPC) Beam For Road Infrastructure Widening

PSPC Concrete technology has in the last three decades been widely used as major structural components in building and construction industry. The technological advancements in PSPC Concrete technology and better logistical capabilities of machineries, such as higher capacity cranes, have enabled larger and longer PSPC concrete elements to be constructed and built into today's road infrastructure projects. Nowadays, many of the flyovers constructed over major road junctions, intersections and interchanges, bridges spanning over rivers and canals, as well as pedestrian overhead bridges are constructed with PSPC concrete elements.

Planning Phase

The launching of PSPC beams is a complicated process which requires advance planning and preparation. This is largely due to the enormous size and weight of these structural elements. In the case of the CTE widening project, proper planning enabled potential risks to be addressed and mitigated – resulting in a smooth and incident-free launching process. The planning of beam launchings were typically conducted in 2 phases, the preparatory activities and actual site surveys.

Preparatory Activities

1. Meeting various stakeholders and agencies, including the Public Transport Operators (PTOs) such as SMRT and SBST to inform them of the actual launch date.

2. Discussing with Intelligent Transport System Centre (ITSC) and Traffic Management (TM) on the traffic needs and demand, and understanding how the portion/stretch of road to be closed will impact on other roads and stakeholders access.

3. Planning road diversions and alternative routes.

4. Notifying emergency agencies, such as SCDF, SPF, and nearby hospitals as well as nearby stakeholders such as businesses and residents in advance.

5. Ensuring advance notices and sufficient signages on the road closures and diversions are provided to all affected stakeholders.

6. Check delivery routes for the precast beams and work out contingency plans for temporary storage along the route in case of transportation breakdown during delivery.

Figure 1: Advance Information Sign

Actual Site Surveys

1. Carry out detailed site study with a crane launching specialist to determine crane launching location and position.

2. Determine whether any affected road furniture, street lighting etc need to be temporarily removed and tree branches that needed to be trimmed. Agencies to liaise with include NParks, and LTA Divisions ITSC and Road Infrastructure Management (RIM).

3. Study and ensure that the ground beneath the mobile cranes is able to support the load during launching

4. Check dimensions of space available on site against the actual beam casted at precasting yard before delivery.

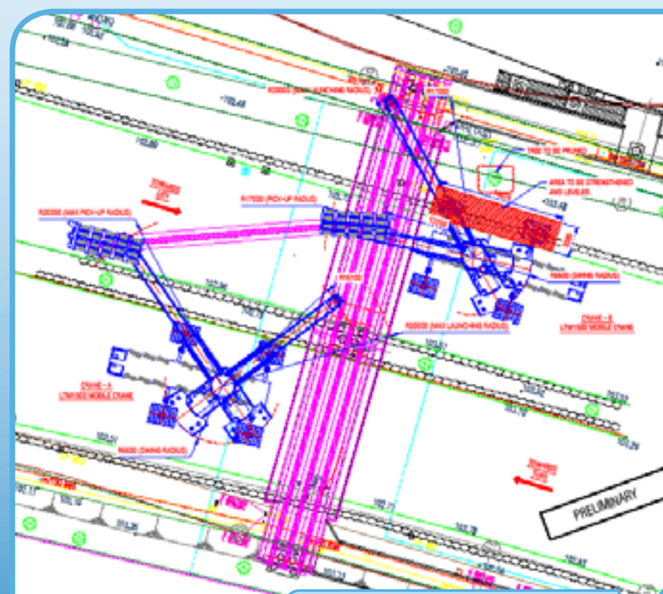

Figure 2: Crane Setting Out Plan

Execution Phase

The launching of PSPC beams typically involves total road closures on expressways or arterial roads for the purpose of deploying mobile cranes and their accompanying accessories (counterweights, lifting gear, etc.). Due to the colossal nature of setting up and operation of these mobile cranes, utmost importance must be paid towards safety in each phase from setting up of the cranes to the actual beam launching.

Setting Up of Mobile Cranes

Lane and road closures must be effected before the arrival of the mobile cranes and accompanying accessories on trailers. Steel plates must be used for the safe sitting of outriggers. After which, the counterweights of the mobile cranes would be installed carefully under the watchful eye of LTA's project team, lifting engineer, supervisor, banksman and safety officer. All these are carried out safely behind barricades and after total road closure. Once completed, the lifting gears will be attached and the mobile crane ready for lifting operation.


Figure 3: Arrival of Mobile Cranes

Launching of PSPC Beams

The lifting gear of the mobile crane will be hooked onto the lifting points on the PSPC beams. The launching operation commences with the slight lift off of the PSPC beams from the cometto and holding in position for 5 minutes to ensure stability of the mobile crane and the PSPC beam. Following which the mobile crane would proceed to slew and / or extend its telescopic boom to bring the PSPC beam to its intended launch position. During the lifting operation, all other personnel are to stay clear of the swing path of the PSPC beams except those authorised using taglines to guide the beam to the intended position.


Figure 4: Hooking up of PSPC Beams

Securing of PSPC Beams

After the successful launching of each PSPC beams, they must be secured by 3 independent systems of restraints to prevent unexpected toppling, dropping or sliding of the launched beams due to unforeseen circumstances. This is especially critical for beams launched over junctions and over live carriageways.


Figure 5: Completion of PSPC Beam Launching

Contingency Plans

To prevent disruption to the beam launching operation, contingency and emergency preparedness plans are well thought through and developed to address any scenarios that may arise. Plans for possible scenarios include the breakdown of trailer or mobile cranes, inclement weather, inability to complete launching within the specified timeframe, temporary storage area for precast elements due to cancellation of operation, etc.

Conclusion

Proper planning and preparation are the most important element in the launching of these PSPC elements. A well thought out and detailed plan will play a huge role in the safe launching of PSPC elements resulting in a smooth operation on the day of launching as well as minimise impact to motorists, stakeholders and workers on site.

Figure 6: Completed Flyover at CTE

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LEARNING FROM JAPAN, HONG KONG & SOUTH KOREA ON MEANS OF CONSTRUCTION NOISE CONTROL

Introduction

In recent years, there has been a rising trend in the number of feedback received on the general issue of environmental noise. To meet the public's expectations for a quieter living environment, a working group comprising of NEA, LTA, URA, NParks, HDB and SMRT was formed to better manage land traffic noise. An overseas study trip to Japan, Hong Kong and South Korea was organised to understand the policies, guidelines and regulations practised in these countries to manage land traffic noise. Although construction noise management is not the main purpose of this trip, the working group found time to visit some construction sites. This article shall highlight and discuss some learning points for the construction noise management processes and mitigation measures adopted by the different countries.

Noise Management Measures

Policies

Permit System Restricting Noisy Machinery Used On Site
In the meeting with Hong Kong Environment Protection Department (EPD), a unique approach to manage construction noise through the use of a permit application procedure was highlighted. Hong Kong's construction noise mitigation measure includes a permit system which requires contractor to apply for a permit to work with certain equipment or machinery during specific periods of the day. This policy allows the free use of powered mechanical equipment in the day (7am-7pm) while the use of percussive equipment would be subjected to the issue of a permit to proceed. During night time (7pm-7am), percussive piling is strictly prohibited while the use of powered mechanical equipment is allowed if the relevant permit is obtained. Such permits can be obtained for duration of a week to 6 months and issuance of permit is based on the noise mitigation measures proposed and the justification for the use of such equipment.

Environmental Impact Assessment

The Environmental Impact Assessment (EIA) is carried out prior to actual work commencement to assess the possible impact a proposed project may have on the environment. In Singapore, an EIA is not mandatory for construction projects unless they encroach into nature reserves.

EIA Requirements In Japan, Hong Kong and South Korea
In Japan, the Ministry of the Environment requires an EIA to be conducted for projects that can potentially cause serious environmental impacts to a broad area of land. Such projects are generally the construction of national expressways, national railways, airports and new urban residential areas.

The Seoul Metropolitan Government has similar requirements. Certain projects listed in the EIA Act will be required to carry out an EIA. Noise and vibration will be taken into consideration at EIA stage for construction sites over 100,000m².

In Hong Kong however, the EIA is mandatory for all construction works according to the Hong Kong Environmental Impact Assessment Ordinance.

Public Participation In The EIA Process
The EIA process in Japan opens up a few avenues for the public to share feedback on the assessment conducted. Contractors would have to consider comments from the government agency and the before projects can commence. Similarly in Hong Kong, the EIA is published to gain public feedback. Comments have to be addressed before the EIA is approved. The approved EIA is then submitted in order for an Environmental Permit (EP) to be issued for civil works to begin. Public participation however, is not required under South Korea's EIA Act.

Public Relation Works

Public relation (PR) with residents in the area is crucial to all construction projects since mutual understanding of needs allows for a smoother progress of the project.

Community Outreach Centres
Part of Japan and Hong Kong's Public Relation (PR) works includes the use of information centres where the public can access information regarding the project. Models, posters and videos display the various construction methodologies used in the project as well as to provide updates on the current construction phase.

Stakeholders Engagement
As part of its community outreach efforts, Hong Kong PR practices also involve monthly stakeholders' engagement and frequent school outreaches. Monthly engagements are usually held in the evening to cater to the working class. During these engagements, updates of the project will be given and stakeholders' concerns can also be voiced out for discussion. School outreaches are carried out for the purpose of informing students and teachers on project works as well as obtaining the school's examination schedule so that noisy works can be rescheduled to avoid coinciding with examination days.

Handing out of flyers containing updates on upcoming works and noisy activities to nearby residents is a common practice for Japan, Hong Kong and South Korea. Such flyers serve to notify residents before noisy works are carried out. This prevents alarming residents when they experience loud intermittent noise coming from site.

Figure 1: School outreach programme

Figure 2: Community Liaison Centre in Hong Kong

Other Practices

Acoustic Enclosure Of Launch Shafts
The total noise enclosure seen on construction sites in Japan surround the launch shafts used for tunnelling works. These enclosures contain all the machinery needed for the soil removal, lifting and lowering of equipment needed for the tunnel boring process. Enclosures are effective in reducing noise especially when works are situated close to residential areas.

Figure 3: Total noise enclosure in Japan

Real Time Display Of Construction Noise
A real time display of construction noise was seen attached to a site hoarding at one of the site visits in South Korea. The LED screen was in full view of the public. This is done to establish accountability to the public with regards to noise emission levels from site. The public can express their concern through a hotline should noise exceed the stipulated noise limits. In addition, real time noise monitoring on receiver's end is carried out by installing noise meters on the nearest noise sensitive receivers (NSRs). The results for both monitoring systems are recorded on an online database system that can only be accessed by the contractor and developer. The data would be used for future noise technology developments.

Figure 4: Installation of display box for the monitoring of construction noise

Other Noise Mitigation Measures

Based on interaction with some Japanese and Hong Kong contractors, the installation of double glazed windows for residents is sometimes necessary based on the recommendations in the EIA. In Hong Kong, schools as well as homes near to construction sites have benefited from the installation of double glazed windows. In some cases where residents are advised to keep their windows shut, subsidy for air-conditioning would also be provided. To date, the provision of double glazed windows at affected schools have benefited 500,000 students

Figure 5: Classrooms with retrofitted air conditioning and double glazed windows.

Conclusion

In summary, construction noise in all three countries is managed from the planning stage and throughout the construction phase of a project. This approach is similar to that practised by LTA even though an EIA is not required at the planning stage. Even with the innovative use of acoustic barriers and enclosures, construction scheduling and public relation works at the construction phase, noise levels generated from construction sites may still deem to be intrusive to the adjacent residents, especially at night. Alternative working methods and quieter technology thus remain the key elements in noise reduction. To continually improve, LTA will organise an overseas learning trip focusing on construction noise in the hopes of learning and adopting the available technology and best practices from other countries.

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Assistant Environmental Manager
Safety Division

LEARNING FROM JAPAN, HONG KONG & SOUTH KOREA ON MEANS OF CONSTRUCTION NOISE CONTROL
SAFETY NEWS

FIRE AND LIFE SAFETY IN WOODSVILLE TUNNEL

Introduction

The Woodsville Tunnel (WVT) connects motorists from Serangoon Road to Upper Serangoon Road, Upper Serangoon Road to Bendemeer Road and MacPherson Road to Bendemeer Road.

WVT was opened to motorists on 28 January 2012 and is the first road tunnel in Singapore to be fitted with a fixed water-based fire-fighting system, in addition to tunnel ventilation system and other standard fire safety equipment.

Figure 1 : Tunnel from Upper Serangoon Road and MacPherson Road to Bendemeer Road

Fire & Life Safety Systems

The fire and life safety systems of WVT are aligned with international best practice and state of the art technologies. The systems are capable of fire detection and verification, implementing emergency response and traffic management plans to provide smoke clear path for safe evacuation and facilitating fire-fighting and rescue operation. Each system does not operate on its own but requires integration with other systems through the Integrated Traffic and Plant Management System (ITPMS) to form a total approach to the management of fire and life safety. The fire and life safety systems are as following below:

- Tunnel Ventilation System (TVS).
- Fixed-water based fighting system.
- Tunnel Linear Heat Detectors (LHD).
- Automatic Incident Detection (AID) and Close Circuit Television (CCTV) cameras.
- Traffic Control Management System (TCMS).
- FM Radio re-Broadcast and Break-in (RBBI) facilities.
- Emergency power and lighting system.
- Tunnel drainage system.
- Emergency niche comprising the following:
  - Manual call point and bell.
  - Flashing beacon light.
  - Fire hydrant system and standby hose.
  - Fire hosereel system.
  - Deluge control valve.
  - Portable fire extinguisher.
  - Emergency phone, power outlet and signage.

Figure 2: Emergency niche at WVT

The Intelligent Transport Systems Centre (ITSC) control room will operate and manage the WVT as an integral part of the ITSC operation. The ITSC operators will take care of the day-to-day front-line operations and management of incidents and emergencies in WVT on a 24-hour basis. The i-transport system via WVT ITPMS will be used to monitor and control all equipment in WVT.

Details of the tunnel fire incident management together with the hot smoke test and emergency exercise conducted before the opening of WVT to public are elaborated below.

Management of Tunnel Fire Incident

The ITSC control room will be alerted of a fire in WVT through any one of the following means:

- Surveillance facilities e.g. AID or CCTV cameras
- Detection facility e.g. LHS
- Call from Singapore Civil Defence Force (SCDF) or Traffic Police (TP).
- Public notifications e.g. emergency telephone or manual call point at emergency niche

The ITSC control room subsequently verifies the fire incident and confirms the location through the CCTV cameras. SCDF and TP are informed using direct hotlines activation at ITSC on the location of the fire, affected lanes, vehicles and casualties involved, access routes, etc. The Vehicle Recovery Services (VRS) crews will be activated to control traffic at incident site, assist in evacuation operations, etc. and will generally arrive in 8 minutes.

ITSC control room will take the following concurrent actions before the arrival of response teams:

- Activate TVS in the appropriate emergency mode.
- Activate fixed water-based fire-fighting system to the appropriate zones.
- Implement full tunnel closure plan using lane use signs, variable message signs, traffic signals and entrance ramp barriers where necessary.
- Activate appropriate beacon lights to warn motorists of the emergency.
- Facilitate traffic downstream of the incident to leave the tunnel.
- Make announcements through RBBI to initiate evacuation.
- Mitigate traffic impact to adjacent road networks.

WVT is provided with a longitudinal type TVS comprising jet fans installed within niches at the ceiling of tunnels. During a fire emergency, the jet fans will be configured to push the smoke towards the exit portal so as to provide the motorists trapped behind the fire incident site with a smoke free evacuation path towards the entry portal.

Figure 3: Typical installation of jet fans at WVT

Typical fire sprinkler systems use individual nozzle heads with glass bulbs which break at a predetermined temperature to release water. The deluge system on the other hand, has open nozzles without bulbs that apply water simultaneously over defined zones in the tunnel.

Figure 4: Deluge system testing

Coupled with the tunnel ventilation system installed in WVT, the deluge system enhances the overall incident management process in the event of fire.

Once the fire incident is over and investigation is completed, recovery operation can commence. The decision to decide whether WVT is ready to be opened to traffic again will be carried out jointly amongst LTA, SCDF and Singapore Police Force (SPF).

Hot Smoke Test

Hot smoke test was conducted to test the effectiveness of the smoke extraction in WVT prior to final completion. Testing is specified by Australian Standard 4391 that provides guidance on the fire size with respect to heat output and ceiling heights in the test space. This ensures that damage to interior finishes does not occur.

Figure 5: Use of fogging gun for smoke generation

This testing method uses a non-toxic, non-pollutant cold smoke injected into the plume of specifically sized trays of burning alcohol. The burning alcohol provides the heat to make the cold smoke buoyant and rise in a manner similar to smoke rising from a real fire but without the attendant noxious, toxic and pollutant fire gases of a real fire. The results of the test confirmed that the design of the TVS is adequate for smoke extraction from WVT.

WVT Emergency Exercise

On 6 January 2012, LTA, together with the SCDF and SPF, successfully conducted an emergency exercise in WVT to test the operational readiness and coordination between the agencies in dealing with potential emergency incidents in WVT. The exercise simulated a collision between a car and a lorry where the car burst into flames. Upon detecting the incident, the OCC immediately activated its emergency response plan to manage the situation.

Figure 6: SCDF's intervention to put out the car fire

Conclusion

The fire and life safety systems inclusive of the deluge system form the integrated fire and life safety systems of WVT. Vigilance of our operators at ITSC, together with the emergency preparedness of agencies such as SCDF and SPF make for a safe drive through WVT.

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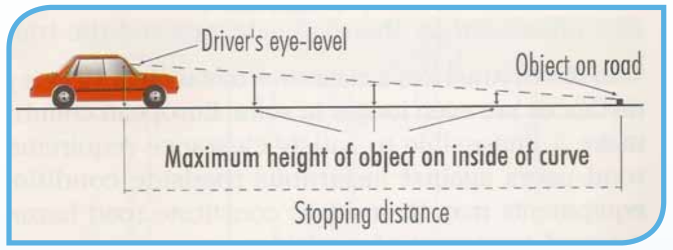
IMPORTANCE OF GOOD SIGHT VISIBILITY ALONG ROADS

Introduction

Visibility is an important and necessary factor to motorists while travelling on a road. Motorists must be able to see the road conditions ahead of them in order to react accordingly. This article will discuss on the various design aspects relating to the need to maintain adequate visibility along the carriageway.

Stopping Sight Distance

One common aspect of visibility is the requirement to ensure adequate Stopping Sight Distance (SSD). While driving, a motorist may have to stop his vehicle suddenly to avoid a potential collision if he notices a perceived hazard ahead. Such hazards could be a vehicle ahead that has stopped suddenly, a fallen crate or tree branch on the carriageway. SSD is the minimum distance required for a vehicle to come to a complete stop from the instance the driver notices the obstacle and applies the brakes.



Design Speed (km/hr)	50	60	70	80	90
Stopping Sight Distance (m)	55	75	95	125	145

Figure 1: Requirement for Stopping Sight Distance

Based on LTA Civil Design Criteria, a driver must be able to see, from an eye height of 1.15m, an object of 0.2m above the road level. The required SSD depends on the operating speed of the vehicle (Refer to Figure 1). For example, for an operating speed of 50 km/hr, the minimum SSD required is 55m.

Visibility Along Road Bends

SSD is particularly considered in the design of road bend by ensuring that there is adequate visibility along the inner radius of the bend.

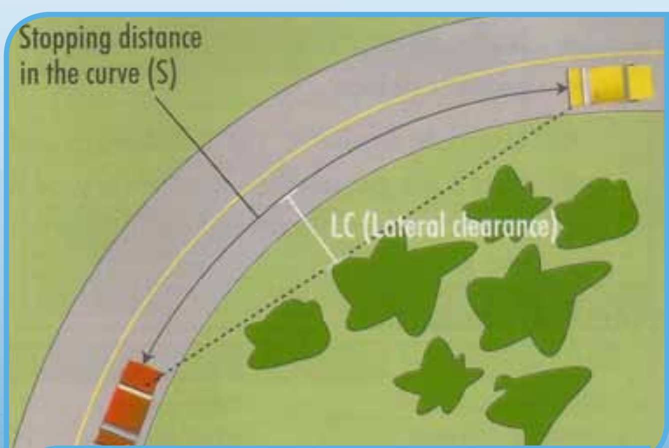


Figure 2: Obstacles such as trees and street furniture that obstruct visibility have to located at a sufficient distance away from the carriageway to enable motorists to see across the road bend

Some examples on the provision of adequate SSD around road bends:

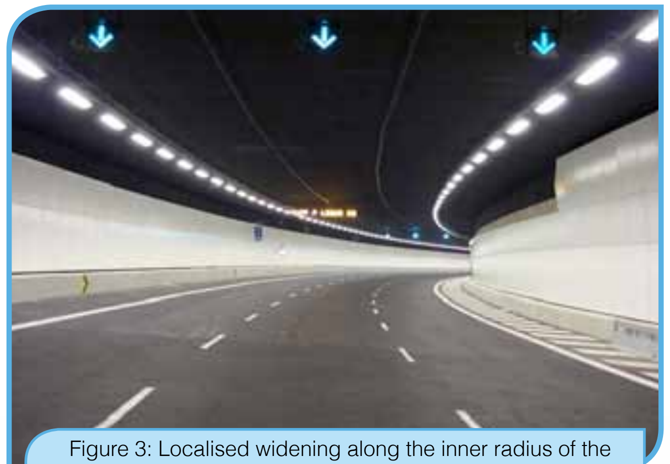


Figure 3: Localised widening along the inner radius of the road bend to provide a wider offset between the carriageway and the tunnel structure

Figure 4: Trees planted away from the edge of the carriageway

Figure 5: At work zones, site hoardings installed across the road bend, rather than along the inner radius

Visibility along Vertical Curves

The presence of a crest or sag of a vertical curve would also have an effect on the visibility along the carriageway.

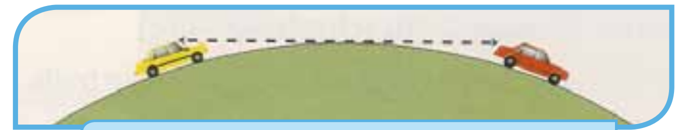
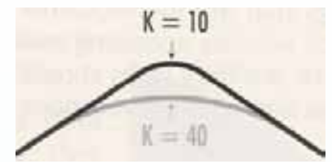


Figure 6: Visibility across the crest of a vertical curve

Figure 7: Visibility across the sag of a vertical curve

$$K = \frac{Horizontal\ length\ of\ curve, L}{Algebraic\ grade\ difference\ of\ \ straight\ segments, A}$$



In general, as the K-value increases, the curve becomes flatter which will provide a longer visibility distance across the crest.

In situations where the vertical curve could not be physically realigned to provide the required visibility due to site constraints, hazard mitigating measures appropriate to the road environment, such as warning signs should be installed to provide adequate guidance to motorists.

Figure 8: Warning signs provided to alert motorists of an up-coming roundabout junction after the crest of the vertical curve

Visibility at Road Intersection

Visibility of traffic signs and traffic signals at junctions

At the approach to an intersection, adequate visibility of traffic signs and traffic signal is necessary to enable motorists to have sufficient time to read the signs/signals, decide and execute the necessary tasks either to stop, turn or go through the intersection.

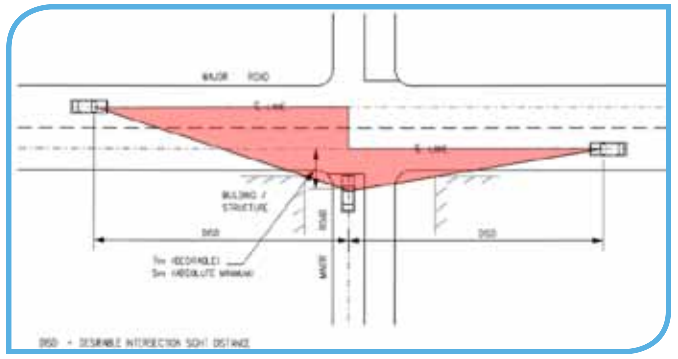
Figure 9: The presence of trees too close to traffic sign would obscure visibility. Based on LTA Design Criteria, trees are to be planted at a minimum distance of 45m and 75m away from advanced directional signs for non-expressways and expressways respectively

Figure 10: Proper coordination in the placement of the street furniture to ensure that the street light pole is located sufficiently away from the carriageway so that it does not obscure the visibility of the traffic signal

Figure 11: Advanced Warning Lights (AWL) provided to alert motorists about the signalised traffic junction after the road bend

Visibility at non-signalised junction

At a non-signalised junction, motorist along the major road would need to have a proper look-out for vehicles from the side road and react accordingly before reaching the collision point when both enter the intersection. The minimum distance needed for the motorist travelling on main road to observe and decelerate to a stop before moving into a collision situation with the vehicle from minor road is defined as the Intersection Stopping Sight Distance (ISSD). Figure 13 shows the ISSD for other corresponding speeds.



Design Speed (km/hr)	40	50	60	70
Stopping Sight Distance (m)	75	100	125	155

Figure 12: Requirement for Intersection Sight Distance

Figure 13: Unobstructed visibility required at Give-Way or Stop junction

Visibility at partially signalised intersection

At a signalised intersection with a partially-controlled right-turn signal phase, it is important to ensure that there is adequate visibility for right-turning vehicles to seek gaps in the traffic flow from the opposite direction to minimise the likelihood of a collision at the junction. If the visibility is limited by the opposite turning traffic queue, then the right-turn movement has to be fully controlled.

Figure 14: Good visibility is required for partially-controlled right turn

Figure 15: A fully-controlled right-turn signal phasing

Visibility of pedestrian crossing

At the approach to a non-signalised pedestrian crossing, such as a zebra crossing along left-turn slip road, having adequate inter-visibility between approaching vehicles and pedestrians at the crossing is important to reduce the risk of pedestrians being hit by vehicle.

Before Improvement: Existing parapet wall obstructs visibility of pedestrian crossing along inner radius of road bend.

After Improvement: Parapet wall reconstructed further away from the carriageway to improve visibility across the road bend.

Conclusion

It is important to provide sufficient visibility for road users in the design of the carriageways in accordance with the relevant design criteria. Due to site situation where the design standards cannot be complied with, a risk assessment is recommended to be undertaken to determine the potential safety concerns and appropriate measures implemented to mitigate the associated risks to a level as low as reasonably practicable.

Mohamed Rozmand bin Jamaludin
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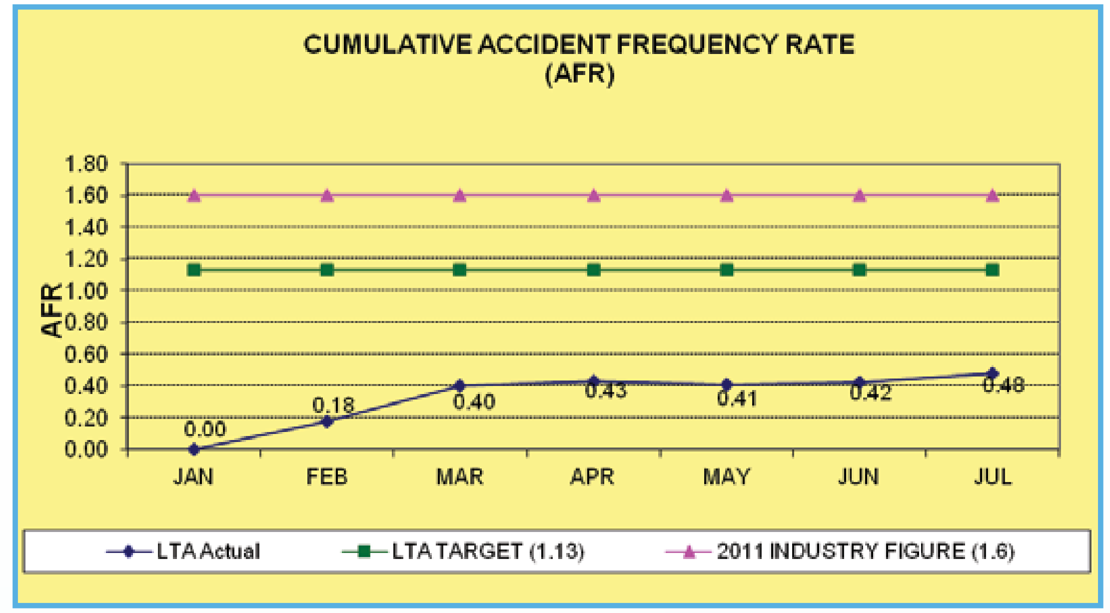
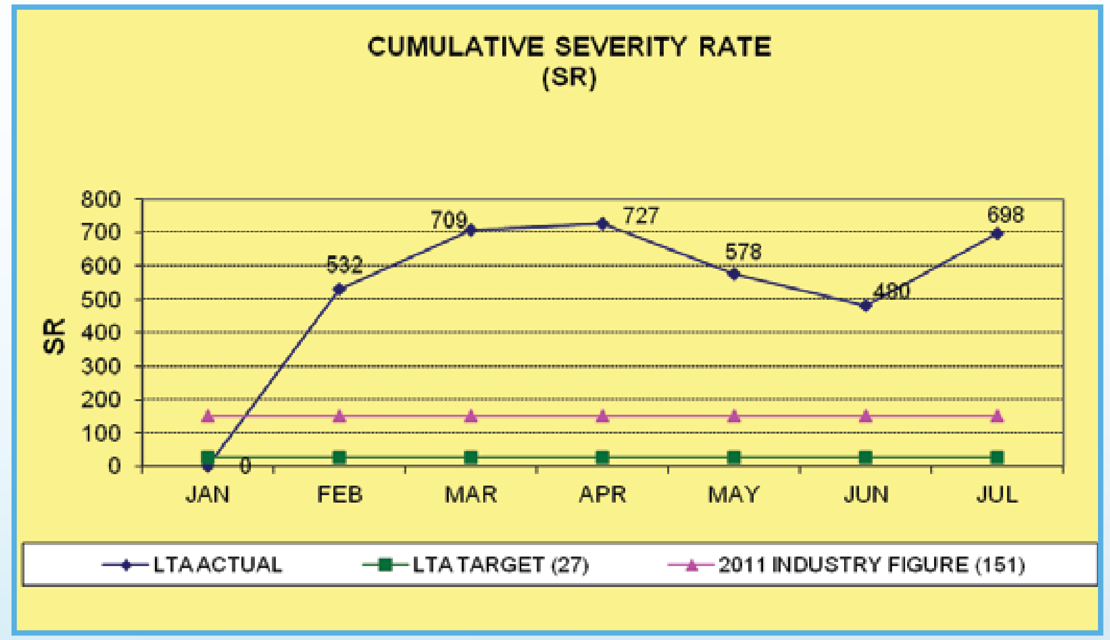
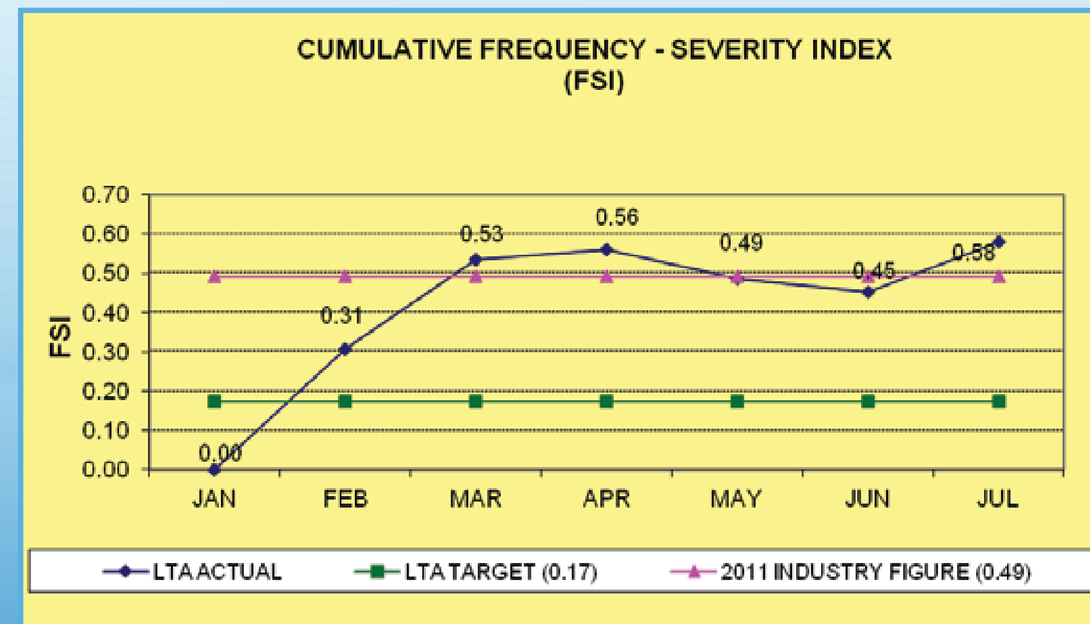
Safety Division

*2012 Accident Statistics







* Based on Singapore Workplace Safety and Health Act Requirements