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The use of heavy machinery is prevalent in the construction industry today. While there is no arguing that machines can greatly increase the efficiency and ease of many work-related tasks, but the interface between equipment and operator or the workman can also pose a significant threat of injury or even death when the required safety precautions are not exercised.

A wide range of heavy machineries are used on site which include, cranes, piling machine, excavators, trailers, shovels, compact rollers and trucks, etc. This article highlights the hazards and some past accidents/ incidents involving the use of heavy machinery on site.

**HAZARDS OF WORKING IN CLOSE PROXIMITY WITH MACHINERIES**

1) Workers endanger themselves by encroaching into / standing within the operation zone of machinery. 
   Consequence - Worker struck by the moving parts of the machine (E.g. worker hit by excavator bucket or pinched by crane’s revolving counter-weight against a fixed object).

2) Insufficient supervision provided during movement (E.g. reversing) & operation of machinery in congested area. 
   Consequence - Worker knocked down by moving machinery or vehicle.

3) Heavy machinery is improperly positioned on poor ground conditions. 
   Consequence - Collapse of machinery.

4) Use of poorly maintained equipment or where the repair work is carried out by incompetent personnel. 
   Consequence - Sudden failure of machinery (E.g. collapse of crane leading to injuries & property damage).

5) Parking of vehicle or machinery on sloping ground. 
   Consequence - Vehicle or machinery rolling down hitting workers or damaging other equipment.

6) Machine operated by untrained and inexperienced person. 
   Consequence - Failure of machinery or workers struck by moving parts of machinery.

7) Poor housekeeping around area of machinery operation. 
   Consequence - Material or equipment being struck by or damage by machinery.

8) Inattentiveness when working around machinery. 
   Consequence - Distracted worker struck by moving machinery or vehicle. (E.g. worker using hand phone).

The following are examples of accidents with serious consequences that have occurred when working near to heavy machineries.

**ACCIDENT CASE STUDY ONE**

- Brief Description
  An excavator was used to lower a 12m long I-beam to the bottom of the excavation for strut installation. In the process, the excavator tilted forward towards the barricade, pinning the rigger/signalman (who was standing below the excavator arm) against the guardrail and sheet pile. The worker sustained severe injuries and died shortly later.

**ACCIDENT CASE STUDY TWO**

- Brief Description
  A rigger was hiding between the crane track and the counterweight, trying to strip some cables. As the crane revolved, he was crushed between the crane’s track & the chassis. The worker died shortly later from severe head injuries.
SAFETY CONSIDERATIONS IN WORKING NEAR MACHINERY

1) Detailed risk assessment must be conducted before commencement of any work to clearly appreciate the potential hazards and to plan for appropriate control measures.

2) Safe work procedures must be developed and communicated to those exposed to the risk.

3) Relevant safety training must be provided for machinery operators, as they could cause an accident due to mishandling of the machinery.

4) Nobody should stand in within the operating radius of any machinery. The operating zone of the machine should be cordoned up to prevent unauthorised entry.

5) Heavy machinery and vehicles like cranes, drilling rig, excavator and trucks need firm ground for safe access and operation. Failure to provide such conditions may result in sudden toppling or collapse of the machinery.

6) Machinery maintenance regime and inspection must be adhered strictly. The Crane Maintenance Supervisor would need to increase the frequency of inspections on machines that are utilised heavily to ensure the parts subject to high wear and tear are replaced.

7) A tagline should be used to control and direct a load into position during a lifting operation. This is to prevent a load from accidentally swinging into workers nearby or into other objects.

8) Heavy machinery ground access should be inspected by competent person regularly. These areas must be identified and demarcated. The lifting team, machine operators and banksman must be informed of such areas on site.

9) Housekeeping must be maintained to prevent heavy machinery from coming into contact with any material and equipment placed on the ground. The heavy machinery can either damage the equipment and material or cause them to move unexpectedly and injure any workers nearby.

CONCLUSION

The severity of injuries caused by coming into contact with heavy machineries is very high; potentially fatal. However, such accidents can be prevented as they are mostly foreseeable. It is important to first recognize the potential hazards and deal with each situation seriously. Only with that right attitude can we rectify/correct them in time to prevent another serious accident/incident from occurring.

Yoong Yew Meng
Senior Executive, Safety & Health
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MACHINE GUARDING

INTRODUCTION

Unguarded moving parts of machinery are major hazards confronted by workers in the workplace everyday. Exposure to dangerous machine parts during operation, examination, lubrication and/or maintenance, pose many risks. Many workplace injuries caused by machinery are preventable. Where the risk cannot be eliminated it must be minimized. In order to reduce the risk, all machinery must be securely guarded to prevent access to dangerous parts. All guards should also be correctly and securely fitted before operating machinery.

MECHANICAL HAZARDS

Unguarded machinery pose mechanical hazards that can cause injury to personnel. Examples of mechanical hazards include:

- **Entanglement with machinery**
  Loose clothing, accessories or hair can be caught by rotating surface or between two moving parts due to rotating, reciprocating, transverse actions. E.g. shaft, pulleys or gear wheels.

- **Cutting hazard from machinery**
  Moving parts or sharp appendages of machinery may seriously lacerate workers. E.g. circular saw, drilling or abrasive wheel.

- **Contact with materials in motion**
  Body parts drawn into moving parts or in-running mid point may lead to shearing or crushing injuries. E.g. running belts or pulley system.

- **Trapped between machine & material**
  Body part trapped between machinery will result in crushing injuries. E.g. ram of forging hammers.

- **Machinery parts or materials ejection**
  Personnel may be struck by flying objects or machinery parts. E.g. bursting of abrasive wheel or flying particles from grinding machine.

WORKPLACE SAFETY & HEALTH ACT (WSHA) & WSH (GENERAL PROVISION) REGULATIONS

The WSH Act stipulates that the employer must, as far as reasonably practicable, protect the safety and health of his employees or workers working under his direct control and all who may be affected by their work.

The WSH (General Provision) Regulations stipulates that fencing or other safeguards provided to safeguard workers from the dangerous parts of machinery must be of substantial construction; properly maintained and always kept in position & properly adjusted while the machinery is in use.

PROTECTIVE MEASURES

- Emergency Stopping Device (ESD) or braking system provided where practicable to stop machinery immediately without creating additional hazards.
- Rotating parts or equipment fastened and secured to prevent dislodgement when brakes are applied.
- All hazardous parts of the machinery provided with fixed, interlock or adjustable guard where practicable.
- Guards are firmly secured and not easily removable where practicable.
- Parts of the machine which may come into dangerous point of operation is guarded for the machine against contact with any body part.
- Warning signage and locking devices to prevent sudden startup when maintenance work is carried out.
- Wear eye protective equipment to prevent flying objects into the eye causing eye injury.

CONCLUSION

Machine guarding is vital to every workplace using machinery. It is an essential protection that employers must provide for their workers.

Contractors need to constantly educate the workers on the hazards of removing the machinery guarding to prevent accidents due to exposed moving parts of the machinery.

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Safety NEWS | Protecting Our Biodiversity During Construction

PROTECTING OUR BIODIVERSITY DURING CONSTRUCTION

BIODIVERSITY IN SINGAPORE

Biodiversity is the variety of species, their genetic make-up and the natural communities in which they occur. It is extremely important in the balance of the ecosystem. It provides people with an array of food and materials to meet our cultural and economic needs. Most medical discoveries were made through research into plant and animal biology and genetics.

Singapore is rich in biodiversity despite our small land mass and intense urbanization. The main key habitats found here are tropical rainforest, mangroves and coral ecosystems. We have more than 2,000 native vascular plant species, some 57 mammal species, 98 reptile species, 25 different amphibian species and 355 species of birds.

EFFECTS OF CONSTRUCTION ACTIVITIES ON BIODIVERSITY

Habitat Destruction and Fragmentation

Habitat destruction occurs when a habitat is removed to make way for a new development resulting in alteration or reduction in biodiversity.

Fragmentation occurs when native habitats become divided into separated fragments due to developments. Fragmentation causes an increase in isolation of population and species, changes vegetative composition, reduces cover and increases edge effect thus potentially increasing rates of predation and competition. As a result, the species may not be able to survive.

Water Pollution to Water Course

Murky water caused by soil, waste concrete, fuels and chemical runoff from construction sites in/adjacent to streams can impact aquatic habitats and plant life. Suspended particles from the runoffs can often reduce the amount of sunlight penetrating the water and disrupt the growth of photosynthetic plants and micro-organisms. This has subsequent effects on the rest of the aquatic community that depend on these organisms to survive.

Hydrology Alteration

Temporary or permanent changes to the underground area that alters the aquifers and water pathways, and thus affecting water levels and water qualities in the connected water bodies, would cause an indirect impact to the flora and fauna.

Road Kills

As construction vehicles and machinery move through the habitats to reach the construction sites, animals which are disoriented by the newly created environment may be killed.

MITIGATION MEASURES CONDUCTED BY LTA

Biodiversity Impact Assessment

In order to minimize the impact of construction activities on the natural biodiversity, a Biodiversity Impact Assessment (BIA) can be carried out at the design stage. Its purpose is to anticipate and prevent, minimize and/or manage, potentially significant negative impacts of development that may incur additional resources to rectify in future, pose risks to our ecosystem or biodiversity, and result in irreplaceable loss of resources and reduced options for future wellbeing.

In LTA, BIAs are executed during the design phase for projects that may threaten our valuable biodiversity resources. For example, a BIA on the construction of the proposed Thomson Line (TSL) Depot, which may affect the ecologies in Mandai and Central Catchment, had been carried out. Literature reviews and field surveys were conducted to gauge the diversity, abundance and distribution of the existing flora and fauna. The walkover surveys were followed up by sampling of forest vegetation involving Quick Plot and Cylinder Intercept Method to assess canopy and under storey vegetation and thus reasonably determines the forest structure, composition and condition. This method involves sampling of three 80 m² (20 m x 4 m) plots established at fixed intervals along transects in the affected area and adjacent areas of the nature reserves.

Wildlife Disturbance: Effects of Lighting, Air and Noise Pollution

Animals respond to air and noise pollution and strong lighting generated by construction activities by altering activity patterns and reduce reproduction levels. Their heart rate will increase, and result in the production of stress hormones.

In Figure 1: Habitat fragmentation (Source: Defenders.org) shown habitat fragmentation is illustrated. Figures 2 and 3: Air pollution from hacking activities and Lighting used during night work demonstrate the effects of pollution and lighting on wildlife. Figures 4 and 5: LTA conducting walkover surveys together with consultant depict the mitigation measures conducted by LTA.
Provision of Green Corridors
Green corridors are usually strips of land or bridge that provide sufficient habitat to support wildlife. The corridors connecting fragmented habitats aid the movement of various animals. It could also act as a buffer zone between ecologically sensitive area and the construction site, thus minimizing the disturbance caused by the site’s activities.

For instance, LTA is currently constructing a 50m wide eco-link bridge linking two nature reserves across the Bukit Timah Expressway (BKE) on behalf on NParks, in order for animals to move between Bukit Timah Nature Reserve and Central Catchment Area. Native tree and shrubs will be planted along the bridge for the animals to colonise.

Preservation of Native Trees and Plants
Native trees should be preserved and protected as far as possible. Where removal of trees is not necessary, a tree protection zone has to be identified and barricades installed to prevent harm to the tree and its branches, trunks and roots. NParks Conservation of Trees and Plants Guideline stipulates the minimum width of a protection zone.

Noise Mitigation Measures and Barriers
Noise mitigation measures commonly seen on LTA sites are useful in reducing noise exposure to animals as well. These measures include:

- Use sound reduced machinery prior to entering the site.
- House noisy equipment in acoustic sheds.
- Barricade noisy activities with portable sound barriers or panels.
- Erect noise barriers before work commences.

Machinery and Maintenance
Use of newer machinery coupled with regular maintenance will help to mitigate and reduce noise and air pollution emission. Where possible, minimize use of generators and machinery running on diesels by replacing with direct power supplies from power plants.

Direction of Lighting
Night work should be avoided as far as possible as the lighting and noise generated will affect nocturnal animals in the way they hunt or forage for food. When lighting has to be used, it should be directed downwards to the ground where work is carried out. The lighting lux intensity should also not be higher than what is necessary.

Use of Alternatives for Chemicals
Chemicals commonly used for environmental control in a construction site include anti-mosquito oil (AM oil), larvicides and thermal fogging for vector control as well as flocculants and coagulants used in water treatment plants for water pollution control. These chemicals are harmful to wildlife that accidentally come into contact with them.

Therefore, environmentally-friendly alternatives should strictly be used. For instance, instead of applying AM oil, Bti (Bacillus Thuringiensis Israelensis) which is equally effective should be used as it is safer to fishes and mammals. Water treatment plants using membrane technology can also be used as an alternative to chemicals application.

CONCLUSION

Biodiversity – the variety of life and of habitats on Earth – is vital to human welfare. The loss or degradation of biodiversity has important economic, environmental, and social consequences.

Preservation of biodiversity requires efforts from all sectors, stakeholders and industries. LTA has contributed in mitigating the impact of construction activities on local natural habitats and will continue to ensure reasonable measures are taken to protect Singapore’s precious flora and fauna resources.

Jernice Kew Huiling
Exec Engineer, Environmental Safety Division
This article describes the safety considerations for the implementation of the North-South and East-West lines (NSEWL) signalling system replacement project (referred as Resignalling Project). It covers strategies to ensure the safety integrity of the existing and new signalling systems are maintained, and to prevent service disruption.

The Resignalling Project will improve the line capacity by providing a shorter service interval (headway) as well as to address the issues on equipment obsolescence and system availability. The existing signalling system has been in operation since 1987.

The main scope of the Resignalling Project comprises the replacement of the existing signalling system of the NSEWL which includes conventional Relay-based Interlocking, Automatic Train Protection (ATP), Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) systems with Communication Based Train Control (CBTC), moving block signalling system and Computer Based Interlocking (CBI).

The Resignalling Project will be implemented in two phases; the first phase covers the North-South Line (NSL) while the second phase is for the East-West Line (EWL).

**PROJECT SAFETY REVIEW (PSR)**

Being the backbone of our Rapid Transit System and the first major resignalling project, it is therefore important to ensure that a thorough assessment is carried out to mitigate and address all potential risks that may arise from this work. This will maintain high availability of train service and system safety throughout the project cycle.

Under the PSR Process, the Resignalling Project is required to make safety submissions to the PSR (Rapid Transit System) Committee as a demonstration of safety achievement at each phase of the project. (i.e. Concept, Design, Handover, and Operation)

The objectives of this PSR process are to ensure:

i) LTA and SMRT have adequate commitments and resources to manage safety effectively and that the system is designed and constructed to achieve high level of safety;

ii) Operator of NSEWL is required to demonstrate that it has the necessary processes in place to operate and maintain the system safely.

Degraded/Emergency modes assessment, Hazard Analysis and Project Safety Assurance Plan are some of the key items required in the safety submissions. The resignalling project team together with contractor will conduct hazard analysis to identify any safety concerns, so that all safety issues could be mitigated to an acceptable level.

As the Resignalling Project involves works on an operating railway, replacement of the signalling system will be rolled out in stages to avoid disruptions to the operational service. Intensive works are expected to begin with the interface of existing signalling system with the new signalling system; followed by the coexistence of both systems and system migration. These works include the dual-fitting of trackside and trains, additions and alternations works to the Signalling Equipment Rooms (SERs), development of detailed strategies for system migration and testing & commissioning plans will be discussed in the following sections.

**i) Dual Fitting**

New signalling equipment will be overlaid with the existing signalling system along the trackside and on the existing trains, i.e. both existing and new signalling systems will co-exist, during the entire project stage. The existing signalling system will be decommissioned after the new signalling system is proved to be reliable from the reliability demonstration test.

Switch-over facilities are provided for the trackside and train-borne to facilitate testing during engineering hours. New system will be tested during the engineering hours and switched back to the existing system for train revenue service. Inspection and test will be carried out at trackside, SER and Operation Control Centre / Depot Control Centre after each system test before handover to the operator for revenue service.

After the new signalling has been commissioned successfully, the switch-over facilities will enable the operator to restore the control of train operation from the new to the existing signalling system in the event the new signalling system fails.

**Figure 1**: Trainborne installation at maintenance track; mounting of antenna on train roof-top (top left) & tachogenerator on the undercarriage (bottom left)

**Figure 2**: New equipment will be installed for this project.
ii) Signalling Equipment Room (SER)
In order to accommodate the coexistence of the existing and new signalling equipment during the entire project stage, additions and alternations works to the SERs will be required. These additional spaces will be provided by SMRT and ready for the installation of the new signalling equipment.

iii) Migration Strategies
a) Migration Plan
Paramount importance is placed on the migration strategies and plans to ensure seamless switchover from existing to new signalling system with no disruption to revenue service. The LTA and SMRT engineers will work closely with the contractor during design stage to develop plans that could best reduce the possibility of disruptions. Phase-by-phase approach with Testing and Commissioning would be carried out zone by zone and adopted as the migration strategy to further minimize the migration risk.

In addition, the whole existing signalling system will be retained and remained operational until it is decided to be decommissioned towards the end of the project. This approach provides fallback contingency operation during the migration stages.

b) Proof of Concept
Changi Airport Line has been selected to be the pilot site for the contractor to conduct demonstration tests prior to the commencement of installation of the new signalling equipment on the NSL. The purposes of the proof of concept are to identify and establish the various methodologies and concepts for the proper signalling replacement at the subsequent project stages. Early system testing also helps to verify that the system has been successfully designed for safe and efficient operations. In addition to the technical assessment, the proof of concept will also provide an ideal training ground for the operational and maintenance staff.

d) Integrated Tests and Test Running
Integrated testing will require the contractor to demonstrate that the new signalling system performs in accordance with the specifications and interface properly with the other systems in the railway, such as the trackwork, trains, communication system, UPS etc. A test running is also necessary to simulate actual operating conditions of the railway system with the electric trains running during engineering hours. The objective is to ensure that the functions and operations of the new signalling system are satisfactorily integrated. A safety case needs to be presented by the contractor and accepted before the system is put into operational service.

e) Shadow Mode
After the trackside equipment along a particular zone has been tested and commissioned, the dual-fitted trains which are certified fit for service will be operated in shadow mode, i.e. the new signalling system will only monitor and collect data inputs during revenue service hours but has no control of the train operation. This approach provides valuable data on system performance for analysis prior to full operation, and enhance confidence that the system performs in accordance with the specifications.

CONCLUSION
In summary, although these plans and approaches could help to mitigate potential risks during the project development, much effort and attention are still required along the way to identify additional risk. Therefore it is always crucial to keep safety as the primary objective at each stage of the project.

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INTRODUCTION

Traffic signs and pavement markings at work zone are essential traffic control devices that provide warning, guidance and information for road users to travel safely through the work zone. In this article, we will look at some common situations encountered or challenges faced in providing appropriate temporary traffic signs and pavement markings at the work zone during the design, implementation and operation/maintenance stages of the diversion. We also highlight some of the measures adopted by project teams in addressing the related issues.

DESIGN PHASE

• Omission of existing details on design drawing

It has been seen that some of the following items are commonly not indicated in the design drawing: existing signs on the road, trees, lamp posts and street furniture of significant size. Arising from the omission of these details on drawing, the proposed location of the traffic signs appear to be clear of any obstruction. However, when the proposed traffic signs are physically installed, some of them are found to be obstructed by existing signs, street furniture or trees such that motorists are unable to see and read them well. The motorists may also be overloaded with information and miss out the important ones if the signs are closely spaced.

It is a good practice that the designer plots out the locations of all existing signs, trees, lamp posts and street furniture so that they can produce a good signage layout plan knowing the available locations suitable for sign installation.

• Traffic signs on narrow centre median and sidetable

Signs such as curved alignment markers (CAM) are designed for installation along the centre median and sidetable to guide motorists to negotiate the bends of the carriageways. The designer may not have considered the narrow width of the centre median and sidetable before indicating CAM signs on them resulting in the actual installed signs to protrude into the live lanes causing possible damage to vehicle and injury to passing motorcyclists. Alternative solution like installing waveline markers, delineator poles or painting of CAM on the barriers wall could be better options.

Similarly, traffic signs mounted beside narrow footpath and close to road edge could likely encroach into the traffic lane or obstruct the footpath. The details shown below is a good practice in guiding construction teams on to need to provide sufficient offsets for traffic signs from road edge.

IMPLEMENTATION PHASE

With a good design of the traffic diversion scheme where the hazards have been designed out, the implemented traffic diversion would naturally have minimum unsafe spots. However, adjustments of the sign and pavement markings may be necessary at times due to site constraint unforeseen by the designer.
in the design stage or the need to adopt modified traffic schemes to facilitate alternative construction methodology. Revision of the traffic control devices during the implementation stage is equally important to be carried out with proper design as it is to be installed with due consideration for the safety at work zone.

• Concrete pavement marking on painted background

In the example below, the project team has taken the initiative to improve the contrast between the pavement marking and the concrete surface to create better contrast of the arrow markings for guidance to motorists.

• Removal of obsolete pavement marking

The pavement markings may be revised according to the different traffic layout schemes designed for each stage of road diversion. In each new stage of diversion, the incomplete removal of pavement markings painted for the previous traffic scheme may confuse motorists. Black paint is not advisable to be used to cover existing pavement markings as it can be seen as lane markings under certain lighting and wet conditions, and may mislead motorists. Therefore, proper and complete removal of the obsolete pavement marking is necessary.

• Improper covering of legends on traffic signs

Some contractors attempt to make use of the sign fabricated for the previous stage of diversion in the new scheme by covering unsuitable legends/arrows with tapes or metal piece to form the intended lane arrangement display. By so doing, the haphazardly modified sign could be misunderstood by the motorists as the information conveyed is ambiguous and sometimes erroneous. Hence, installing the proper sign showing correct and relevant information accurately and clearly to motorists is essential.

During the operation and maintenance phase, the common problems are the use of dirty or damaged sign and worn-off pavement markings. Dirty and damaged signs should be cleaned or replaced with new one.

• Worn-off pavement marking

Pavement markings could wear off as a result of heavy traffic volume plying over them or removed by trenching and pavement patching works. Worn-off marking gives incomplete information or confusing guidance to motorists travelling through the work zone.

Contractors need to establish regular inspections/maintenance regime with follow-up rectification on defective signs and worn-off pavement markings among other traffic control devices. Proper and clear signs coupled with conspicuous pavement markings need to be maintained throughout this operation phase for safe traffic movement around the work zone.

CONCLUSION

Good practice and effective measures in ensuring safe traffic control at work zone are recommended to be adopted in the relevant design, implementation and operation/maintenance phases. Traffic signs and pavement markings are vital traffic control devices that shall be incorporated appropriately in the traffic scheme. It is always advisable that due consideration to them be given as early as in the design stage. By doing so, the undesirable arrangement and associated hazards will not be translated into the physical implementation. Otherwise, adjustments of the signs and pavement markings ought to be done where necessary to adapt to site constraints. Only then will the traffic signs and pavement markings provide adequate warning, guidance and information to road users travelling through a work zone.

Loh Kok Fah, Chris
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SAFETY PERFORMANCE STATISTICS

2011 ACCIDENT STATISTICS*

* Based on Singapore Workplace Safety and Health Act Requirements
On 31st January 2012, more than 130 officers from Rail, Road Projects and Engineering Groups attended the annual LTA Safety Retreat conducted by Safety Division. The retreat served as an excellent forum to review LTA’s safety performance of 2011.

The retreat was well-received as participants reaffirmed their commitment to safety through active discussions on setting new corporate safety targets for the next three years, and implementing new measures to achieving them. The session culminated with the formation of several innovative and effective ideas that are listed as key safety initiatives to be implemented on sites in future. In addition, target Accident Frequency Rates (AFR) and Severity Rates (SR) to be achieved within the next three years were set, with a successive improvement of 6% each year.

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AFR And SR Targets For 2012 To 2014

The next Road Safety Reviewer Accreditation Course is scheduled for 22-25 May 2012. The 4-day course is targeted for interested parties who wish to become Accredited Road Safety Reviewer in Singapore. With the accreditation, they can undertake safety reviews for LTA road projects.

As the course requires participants to read drawing plans consisting mainly of traffic layout plans, site plans, longitudinal and cross-sectional details, it is recommended for those with at least 1 year experience in road and traffic engineering.

Interested LTA staff can apply through the Learning Roadmap via HR Links. External consultants interested in this course can obtain a copy of the application form from LTA Academy.

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