

Safety NEWS

DRIVING SAFETY EXCELLENCE THROUGH BEHAVIOUR BASED SAFETY

FEATURED ARTICLES

- 02** Behaviour Based Safety (BBS) Implementation in LTA Worksites
- 04** Safety in Erection of Steel Strutting for Deep Excavation
- 06** Safety Challenges of Construction Works in Highly Built-up Areas
- 09** LTA Carbon Asset Management
- 11** Safety Considerations for Construction Site Access
- 13** Testing of Safety Features for C151A Trains



BEHAVIOUR BASED SAFETY (BBS) IMPLEMENTATION IN LTA WORKSITES

INTRODUCTION

Behaviour Based Safety (BBS) was first applied in industries and/or countries seeking to further improve safe workplace behaviours since the mid 1970s. BBS is a proactive approach by focusing attention on at-risk behaviours that can lead to an injury. Based on research of the “accident pyramid”, the large numbers of unsafe behaviours and conditions at the bottom of the pyramid will inevitably lead to a fatality. ¹Studies have also shown that there are about 96% of unsafe behaviours compared to 4% of unsafe conditions. Therefore, reducing unsafe behaviours can help eliminate serious accidents.

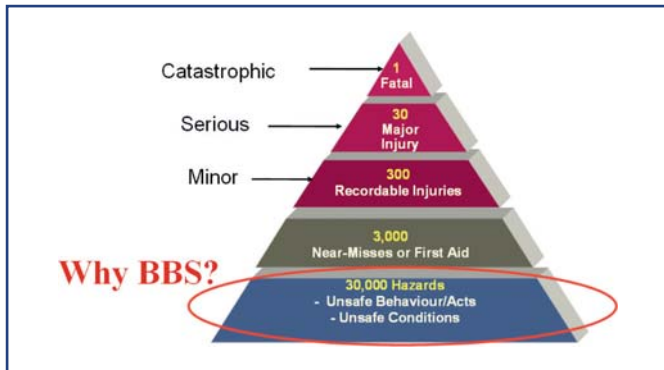


Figure 1: Accident Pyramid

In the 2009 benchmarking assessment on LTA's Occupational Safety and Health Management System by DuPont Safety Resources, a key recommendation was to place more emphasis on reducing unsafe behaviours to help LTA achieve world class safety performance.

BBS CONSULTANCY SERVICES

LTA embarked on BBS by engaging a Consultant to provide consultancy services in April 2010. The pilot programme was implemented on a Rail project (Downtown Line 1 Contract 903) and a Road project (Marina Coastal Expressway Contract 486).

• Safety Culture Survey

The implementation started with the Safety Culture Survey to measure the beliefs, values and attitude towards safety in both LTA and the two contractors. In addition, the survey findings will determine the readiness of the contractors to embark on BBS implementation. The survey was conducted on selected LTA's top management and project management staff as well as Contractors' management staff and workers.

A combination of interviews and survey forms were used to identify strengths and weaknesses by measuring the organisation's perceptions about the effectiveness of the current safety climate of both LTA and the contractors.

The survey was kept anonymous and confidential to encourage honest responses from the participants so as to obtain findings on the true safety climate of the organization. Interpreters proficient in the languages of the foreign

workers were engaged to ensure the survey was clearly understood and effectively conducted. These interpreters were trained by the Consultant on the concept, objective and procedure of safety culture survey.



Figure 2 : Interpreter briefing the foreign workers on the survey form.

• Baseline Observation And Intervention Strategies

A baseline observation is an initial benchmark to establish the safe and unsafe behaviours by observing workers without any intervention strategy to correct any unsafe behaviour. The observation is conducted based on an established checklist of critical behaviours.

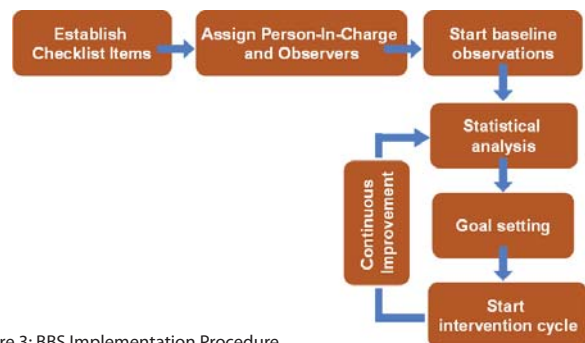


Figure 3: BBS Implementation Procedure

Based on results of baseline observation, a goal-setting committee comprising LTA staff, main contractor and subcontractors was formed to set achievable targets for safe behaviour improvement for the critical behaviours and monitor intervention results based on the Consultant's recommended intervention strategies. The strategies adopted by the Consultant were:

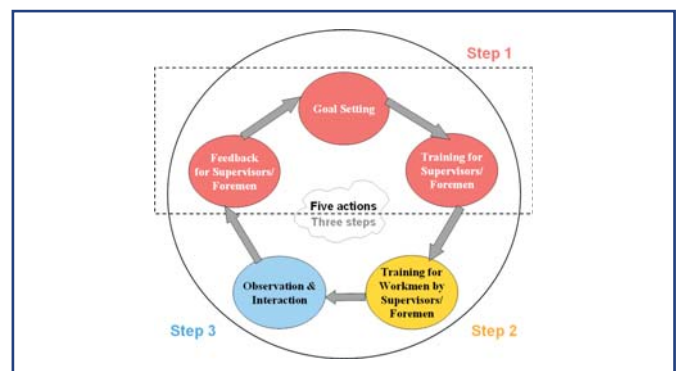


Figure 4: BBS Intervention Cycle

¹ Results of ten year DuPont study, Safety Training Observation Program, E.I. Du Pont, Wilmington, Delaware (1986).

1. Feedback to the supervisors on the observation results and causation of unsafe behaviours;
2. Train the supervisors to train the workers on the necessary actions to be taken for improving safe behaviour; and
3. Discuss and set new achievable goal for the next observation cycle.

Continual observation and intervention cycles were carried out in cycles of 2 weeks. 3 cycles were carried out for the pilot programme. Marked improvement in safe behaviour was noted at the end of the pilot programme.

• BBS Tracking And Analytical Tool

The BBS implementation programme developed for LTA covers the conduct of safety culture survey, baseline observations and intervention strategies. To complement the implementation programme, a software was designed with functionalities to manage and track behavioural observations for trend analysis as well as set targets for continual improvement. It is an internet-based platform designed to help our contractors in implementing and monitoring BBS programs on LTA worksites.



Figure 5: Sample screenshot of the BBS Tracking and Analytical System.

• BBS Training Program

In addition, the Consultant customised a “Train-The-Trainer” training program so that both LTA and its contractors can conduct their own training and implement BBS on their respective worksites as well as to spread the understanding of BBS. It covers the understanding and techniques of :



Figure 6: BBS training conducted for LTA and Contractors' staff.

1. Conducting Safety Culture Survey;
2. Behavioural observation and intervention;
3. Setting targets for behavioural improvement; and
4. BBS Tracking and Analytical System.

CONCLUSION



“To sum up the Behaviour Based Safety Programme arranged by LTA & conducted by the Consultant in one sentence: It has improved our safety attitude and performance. With the guidance from the Consultant representatives, we initiated a change to our day-to-day safety routines to integrate the BBS philosophy. We are firm believers in training and rewarding the workforce to ensure safe practices, rather than simply punishing them for their

dangerous deeds. BBS has simplified the learning process and made it more understandable to the workforce. Keeping in mind that we had a wide array of nationalities and languages on our worksite, the Consultant had customised the training material for ease of understanding to the workforce. Generally, translations are made orally to the workers. Since the Consultant representatives have been implementing BBS with various companies in many countries, their wealth of knowledge and expertise made implementing BBS on our site a simple task. This work was reflected in the good results where we improved our baseline score. With the continual application of BBS, we aim to eradicate accidents to create a safer site for all our workmen.”

Mr Patrick Braun
Project Manager, DTL1 C903
Soletanche-Bachy - Koh Brothers JV



“The BBS pilot trial on C486 has enhanced our ability to identify the actual root cause of safety lapses on site. In ensuring no communication barrier, I have an open door policy to ensure safety issues are reported to me directly from any site personnel. As BBS requires ownership of safety matters, the process of building trust and providing empowerment to individuals is important in creating and sustaining a positive workplace safety culture. In short, the implementation of BBS has established a proactive, positive and open approach to safety in our work environment.”

Mr Chung Hoi Yong
Project Manager, MCE C486
Samsung C & T Corporation

Although the Consultant concluded the BBS consultancy services in Jan 2011, moving LTA and its contractors towards world-class safety standards is a never-ending journey.

To implement a sustainable BBS program successfully, an organisation must have a good occupational safety and health management system along with a mature organisational safety culture in place. BBS is suitable for committed organisations that are willing to deploy sufficient resources.

Correct implementation of BBS is highly effective in improving safety performance.

Leong Choong Yiok
Senior Executive, Safety & Health
Safety Division

SAFETY IN ERECTION OF STEEL STRUTTING FOR DEEP EXCAVATION

INTRODUCTION

Safety in erection of steel strutting is of increasing importance as steel struts are commonly used for civil engineering works.



Figure 1: Double wall cofferdam construction at MCE Contract 485

The Marina Coastal Expressway (MCE) Contract 485 involves the construction of double wall cofferdam with four to five layers of steel strutting as temporary earth retaining structure.

This article provides guidance and advice on how steel strutting can be erected safely.

PLANNING STAGE

The pre-planning stage is to identify, assess and control workplace hazards. Therefore, the following components are essential :

- Site layout has to be planned carefully to ensure that there will be adequate access routes into the site for safe delivery of equipment, machinery, materials, as well as safe access for workers.



Figure 2: Adequate access route to ensure safe delivery and movement of machinery and materials

- Pre-planning of all lifting operations to ensure that all requirements are met. The sequence of erection activity, material staging, material storage and co-ordination with other trades and construction activities have to be taken into consideration.

- Ensure deployment of qualified workers with adequate training and relevant experience to safely perform the assigned work. On-the-job training shall be provided and supervised by competent personnel.
- Establish a fall protection plan which specify all falling from height hazards at the worksite and fall protection system to be used.

LIFTING OPERATION

Proper communication is essential for the safety of personnel. Prior to work commencement, every worker must be informed of safe work procedures for strut erection and usage of equipment or machinery. Ensure that risk assessments are communicated all the way down to individual workers to ensure that safety consciousness is already in place during the initial stages of the steel strutting erection.

Before commencement of any lifting operation, consider prevailing ground conditions and whether soil compaction is necessary in areas which cranes are moving and operating. Cranes must be setup on firm ground and level surfaces suitable for the intended activities. The crane operator must be qualified and competent to perform the lifting operation. Visual inspection by crane operator for all the crane components is required before performing the job.



Figure 3: Crane setup on firm ground and level surface



Figure 4: Ensure that workers are not required to work under suspended loads

SAFETY IN ERECTION OF STEEL STRUTTING FOR DEEP EXCAVATION

All loads being lifted must be pre-planned to ensure that no employee works directly below a suspended load. Workers must stay out of the danger zone created by moving equipment or loads to prevent accidents.

Qualified rigger shall rig and inspect the load prior to each lift and tag line shall be used to control the load. Steel erection must be done under the supervision of a competent person who is present at the work site.



Figure 5: Use of tag line to control the load

Minimize manual handling of loads or materials by workers. Provide appropriate equipment to help workers handle heavy or irregularly-shaped loads.



Figure 6: Appropriate machinery to help worker handle heavy or irregularly-shaped loads

SAFETY CHALLENGES

The biggest safety challenge in erection of steel strutting is that workers are required to work at height. The fall protection plan has to be strictly followed to protect workers from falling from height. Training has to be provided to all employees exposed to falling from height hazards.

Boom lift or tower scaffold can be used as an alternative during the erection process as a working platform for the workers.



Figure 7: Use of boom lift as an alternative for working at height

It is also important to maintain proper housekeeping at the worksite. Perform ongoing cleanup as required.



Figure 8: Proper storage of materials and maintain good housekeeping at work site

Supervisor can exercise judgment and halt all work activities due to inclement weather conditions.

CONCLUSION

Every individual working in the construction industry must take responsibility for safe work practices, regardless of the job title. It cannot be assumed that safety is someone else's responsibility. Safety is everyone's responsibility.

Koh Eng Seng

Senior Project Manager

MCE C485 Subcontractor

Yongnam Engineering & Construction Pte Ltd

SAFETY CHALLENGES OF CONSTRUCTION WORKS IN HIGHLY BUILT-UP AREAS

INTRODUCTION

The Downtown Line Stage 2 (DTL2) is a fully underground Rapid Transit System (RTS). It runs along the Upper Bukit Timah Road/Bukit Timah Road corridor, serving largely the public housing estates of Bukit Panjang and Choa Chu Kang in the northwest with a direct access to the city centre. The total length of the proposed route of DTL2 is about 16.6 km.

Stevens Station, one of the proposed stations in DTL2, is a design and build project under Contract 919. It is located east of the major road junction before intersection of Bukit Timah Road and Stevens Road. The surrounding consists of a mix of high-rise residential blocks and low-rise buildings as well as shophouses and a school. Adjacent to the station is the Wayang Satu Flyover. The Bukit Timah Canal runs parallel to the flyover.

In view of the relatively small footprint of the worksite and the close proximity of the surrounding structures, the project team faced many challenges during the construction works. This article details these challenges and how the project team, working closely with the contractor and stakeholders, managed to overcome them, ensuring that the work is carried out safely and on time.

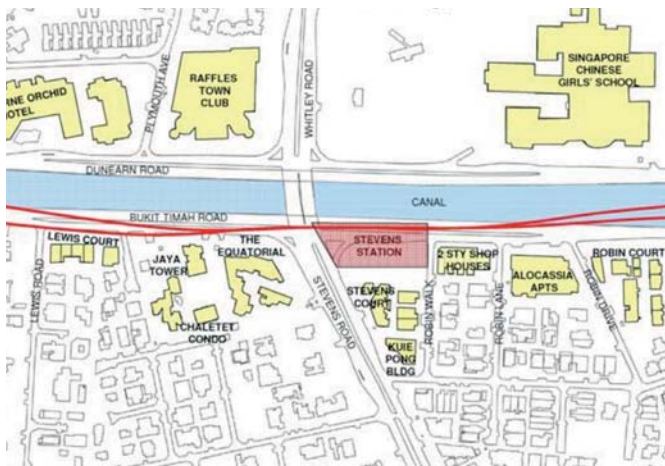


Figure 1: Stevens Station's location



Figure 2: Artist's impression of the exterior design of Stevens Station

NOISE POLLUTION

The ambient noise level (road noise), based on baseline readings taken earlier along the Stevens Station worksite had already exceeded 55dBA and hence very little margin was available to cater to construction noise without exceeding the legal limits imposed by NEA.

To minimize noise nuisances to the nearby residents, noise barriers were erected along the shared perimeter, lifting machines and generators were enclosed with noise absorbing panels as well as the selection of less noisy machinery. In addition, the contractor carried out a strict machinery maintenance regime to ensure that all machinery were in good working condition without being unduly noisy.

In addition to the administrative measures, the public relation team also engaged the stakeholders by:-

- i. Informing them ahead of construction works that would be carried out past midnight;
- ii. Distributing brochures / technical handouts to gain their understanding on the work activities;
- iii. Fostering good relationships with the stakeholders through various activities, such as site visits.



Figure 3: Noise barriers installed to contain noise



Figure 4: Erecting noise barrier around the worksite

ACCESS RESTRICTION

In order to facilitate the construction of Stevens Station, Robin Walk was closed to vehicular traffic from Bukit Timah Road and only accessible by foot. To minimise the inconvenience caused to the residents, the project team worked closely with the contractor to ensure that proper and safe walkways were provided and maintained so that the residents could still gain access to Bukit Timah Road by foot.



Figure 5: Ensuring adequate walkway/access spaces

SITE CONSTRAINT

Given its relatively small footprint, congestion on the worksite is aggravated by the large number of heavy machineries for the diaphragm wall construction, silos for the batching plant as well as several 8-foot containers which served as site offices and storage.



Figure 6: Space constraint on site

Safety is a primary concern on the congested site as there is little room available for the safe access of heavy machinery on site. In addition, the working radius of the individual lifting machine must be strictly monitored and enforced to minimise the potential of collision during lifting operations.

To lessen the site congestion, the project team worked closely with the contractors to find alternative areas for the storage of the less critical entities such as the 8-foot containers. The project team managed to secure the use of the vacant land beneath the Wayang Satu Flyover (located opposite the worksite) to house the 8-foot container site offices as well as to serve as a storage yard.



Figure 7: Using spaces beneath the flyover for container offices and storage

In addition, the project team also managed to secure a piece of vacant land at Eng Neo Road (short distance from the worksite) to store the steel reinforcement bars / cages thereby reducing the congestion on site. With this external storage area, the contractor implemented the Just-In-Time (JIT) delivery process to ensure that the material would be delivered to site as and when required.

POTENTIAL SETTLEMENT TO NEARBY STRUCTURES

As the deep excavation for the construction of the Stevens Station is carried out very close to the Wayang Satu Flyover, residential units and shophouses, the potential for ground settlement and damage to the nearby structures are very real, especially for the row of shophouses which are supported only on footings and not piled foundations.

To mitigate the risk of settlement to nearby structures, the top down construction approach was adopted using adequate strutting at every level of the excavation to reduce the likelihood of deflection and settlement. In addition, extensive instrumentation is deployed to carry out round the clock monitoring of ground movement.



Figure 8: Settlement of the nearby shophouses (patched up with cement)

TRAFFIC DIVERSION ALONG BUKIT TIMAH ROAD

To facilitate the temporary works as well as construction of the station-box, the traffic on the heavily used Bukit Timah Road had to be diverted in several stages. For every stage of diversion, the project team carried out meticulous planning to ensure that ease of traffic flow and the safety of both the motorists and pedestrians were not compromised.



Figure 9: Road diversion schematics

One such example of this meticulous planning was the re-alignment of the slip road to Stevens Road carried out on Sunday, 20 March 2011 (as part of stage 2 road diversion). Road markings and removals started at 1900 hours. With the assistance of AETOS to conduct traffic control, the contractor disabled the existing traffic lights at junction of Bukit Timah and Stevens Road and concurrently activated and synchronized the new traffic lights installed. The bus number pole and bus guide at the bus stop were shifted. The new slip road was opened to the public at 0230 hours, 21 March 2011, 7 ½ hours after the road diversion started.



Figure 10: Completion of road diversion

CONCLUSION

Through continual assessment of site situations, careful consideration of potential outcomes, close liaisons with stakeholders and contractor, coupled with brainstorming sessions, the project team is able to rise up to the challenges of construction work in the built-up area, and have effectively mitigated the challenging issues thus far. Further challenges will bound to surface as we continue with the project, but the project team is determined to resolve them swiftly and efficiently as and when they arise.

Christopher Tan
Executive Project Engineer
DTL2 C919

INTRODUCTION

Increasing extreme weather events, erratic and unpredictable weather patterns are happening around the globe. Several months back in December 2010, we saw the freak winter storm that crippled the United Kingdom's land as well as air transportation systems, leaving thousands of commuters and travelers stranded. A friend in the UK even described that it was impossible to leave her home to buy food. Happening almost back to back one month later, "a huge winter storm, described as the worst in decades, has brought much of America's heartland to standstill, closing airports, main roads, schools, colleges and government offices" reported the Guardian, UK. Last but not least, described as never-witnessed-before flash floods hit Thailand's southern provinces and killed 41 people in April 2011.



Figure 1: April 2011's flash floods in Southern Thailand killed 41. Source: Climate Signals

Back in Singapore, weather is not that much predictable and soothing too. During the recent General Elections Polling days, temperature hit a high of 35°C, compared to similar period last year; temperature was at an average of only 31°C. Projections from the recently released Singapore's Climate Change Study report indicated that temperature will only continue to increase among a host of other climatic changes that will happen in Singapore. There can be many implications on LTA, some of which include elevated risks on the physical and operational resilience of our transport infrastructures, traffic flow, commuters' door-to-door travel experiences and construction progress of our current and future projects. Specifically to our infrastructure development projects, due to increasing ambient temperature and the inherently high humidity, we may face increasing heat stroke incidences and vector breeding. Projected increases in precipitation and extreme rainfall events may also hinder progress of our construction works.

The general approach taken by the international communities to address the issue of climate change is to adapt to the already changing climate, mitigate further upset of the climate and increase the understanding of the issue.

MANAGING CARBON DIOXIDE IS THE KEY

There is common consensus among scientists¹ and agreements from world governments² that climate change is undeniably happening and carbon dioxide (CO₂) being the main culprit. CO₂ released into the atmosphere acts as a sponge for heat, capturing and retaining heat that was supposed to leave earth's atmosphere. Widespread movements have since been initiated worldwide to control CO₂ emissions in an attempt to mitigate further upsetting of the climate systems. In LTA, as part of our environmental responsibility, we have also launched a framework of carbon management for our projects in year 2009.

This framework³ seeks to quantify the Cradle-to-Gate⁴ amount of CO₂ that each of our projects has caused to be released into the atmosphere. "You cannot manage what you do not measure". With this information, decision makers and stakeholders like LTA's management, designers and project teams can understand the environmental costs of a project and deliberate on our approach. MCE, DTL1 and Woodsville Interchange were the first projects to participate in accounting for their carbon footprints.

RESULTS FROM THE PILOT CARBON ACCOUNTING

Results for MCE indicated that the project's total carbon footprint was 540 ktons-CO₂ for the period of August 2009 to July 2010. 6 sources of carbon emissions (combustion of diesel on site, demand for grid electricity, concrete, prefabricated concrete, metals and asphalt) were tabulated and 3 were found to be the significant contributors to the overall carbon emissions from MCE project.

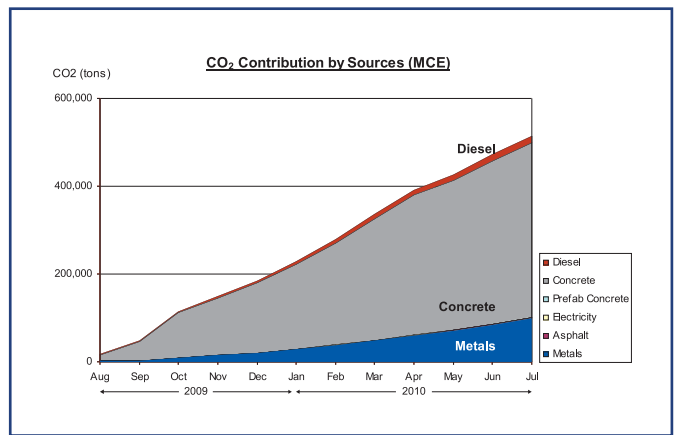


Figure 2: CO₂ Contribution by Sources

Figure 2 above shows the contribution of the CO₂ emission by the various sources. The usage of concrete (74%) was the largest contributor followed by metals (18%) and diesel (7%). CO₂ emitted due to the use of grid electricity, asphalt and prefabricated concrete amounted to less than 1%. While the results of MCE is not conclusive that all other projects will behave as such, this information has allowed us to form some understanding of our emission patterns so that we can focus our mitigation strategies and resources at where it matters most.

¹ Referring to scientists participating in the Intergovernmental Panel on Climate Change (IPCC)
² All findings and conclusions on climate change published by the IPCC are endorsed by world governments
³ Framework of Carbon Asset Management for projects can be referred to in Oct 08 edition of Safety News
⁴ Cradle-to-Gate is an assessment of a partial product life cycle from resource extraction (i.e. cradle) to the factory's gate (i.e. before released for consumer use)

POTENTIAL FOR REDUCING CO₂

With the data from the carbon accounting exercise, further analysis testing the abatement potential of mitigation measures specific to the project is possible. A simplified wedge analysis⁵ was performed on MCE to assess the potential CO₂ abatement of several measures available in the market. Such analysis is often conducted to provide an insight to the maximum abatement that can be achieved by each respective measure. Measures being considered include replacing diesel with Waste Cooking Oil (WCO) biodiesel and replacing cement content of concrete with established substitutes i.e. fly ash, blast furnace slag. WCO biodiesel is fuel converted from recycling waste cooking oil and has a lower lifecycle⁶ carbon footprint compared to conventional diesel. Replacement of cement content with fly ash or blast furnace slag is technically feasible and tried⁷ and its carbon abatement potential is well documented by Bath University⁸.

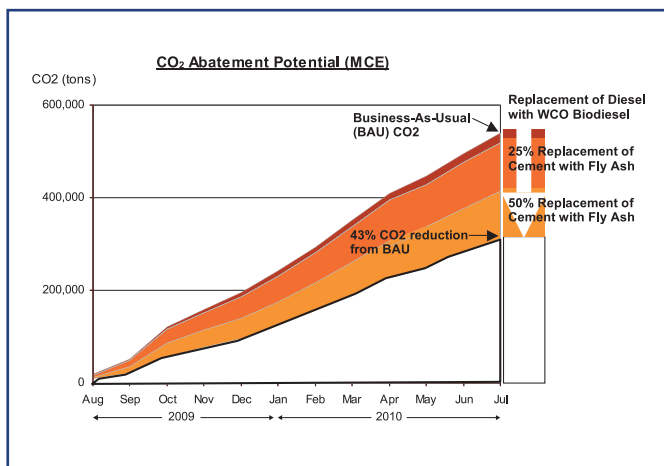


Figure 3: CO₂ Abatement Potential

Presented in Figure 3 above, each colored wedge indicates the amount of CO₂ that can be abated by the respective mitigation measure. For example, the first wedge indicates that the substitution of diesel to WCO Biodiesel can reduce Business-As-Usual CO₂ emissions by 20kton (4% reduction). Replacing cement in concrete by 25% fly ash can reduce CO₂ emissions by 19% and a further 20% reduction can be achieved with 50% replacement. In this proposed package of mitigation measures, a maximum potential of 43% reduction in CO₂ emission can be attained. Apart from the measures considered in the test, there are other mitigation possibilities such as replacement of cement with blast furnace slag, designing out carbon, improving resource management, better waste management and increasing process efficiency which can be considered by various stakeholders along the value chain.

WAY FORWARD

Since the launch of this framework in 2009, enhancements have been implemented to cater for the accounting of various established mitigation measures. Continual enhancement of the framework will be periodically undertaken in order to take in newer and more innovative mitigation measures. Currently, trials are being conducted in collaboration with Ssangyong in MCE C482 to test-bed the feasibility of adopting WCO biodiesel on our sites. Moving forward, we plan to conduct cost effectiveness and feasibility studies on the replacement of cement with fly ash. With enough data, we can also benchmark our projects with international projects to learn and share experiences in carbon mitigation. Most importantly, innovation and out-of-the-box thinking will enable us to engineer CO₂ out of the way we build and this would need to come from everybody. Hence, we will also be engaging stakeholders along the value chain exploring possibilities to continually reduce our project's carbon footprint.

CONCLUSION

The Carbon Asset Management is a tool which provides a means of measurement so that every stakeholder can quantify their carbon mitigation efforts. The system will also help the organization look beyond localized environmental protection (noise control, vector management and earth control) to the bigger picture of global environmental stewardship (issues of climate change).

Singapore is a very small country, our efforts in mitigating CO₂ is minuscule compare to bigger emitters, but however, it should not stop us from doing our part as a responsible developer. In doing so, we can also encourage bigger emitters that it is possible to build and develop in a climate friendly way.

Other than mitigation, another aspect of climate change is ensuring our projects are adequately adapted to the already changing climate. A framework on *Climate Change Adaption for Projects* is currently being developed to assess the risks changing climate will put on our projects and how to adapt to those impacts.

Lester Chan Cheong Shuen
Executive Engineer, Special Duties
Safety Division

⁵ Adapted and simplified from Socolow and Pacala's Stabilization Wedge Game

⁶ Information from published paper: 'Lifecycle emissions and energy study of biodiesel derived from waste cooking oil and diesel in Singapore'

⁷ Examples of use include substructure works in Pulau Seraya Power Station, bored micro piling in Exxon's project in Pulau Ayer Merbau and structures in LTA's Kallang Paya Lebar Expressway C421

⁸ Bath University's Inventory of Energy and Carbon

INTRODUCTION

When designing work zones, designers need to give proper considerations in providing safe locations for the access/egress to the work site. They also need to appreciate the operating characteristics of construction vehicles in these areas.

Construction vehicles being wider and taller than passenger cars generally have a restricted/lower speed limit. Drivers of these vehicles also have limited view of their rear especially while transporting loads/equipments. These drivers depend a lot on their side mirrors to check for blind spots while travelling.

DESIGN CONSIDERATIONS AND PRACTICAL SOLUTIONS

Important design considerations and practical examples on solutions taken to tackle the problems associated with designing work site accesses are described in the article.

• Limit The Number Of Work Site Accesses

While formulating the design of the temporary traffic control scheme, the designer/contractor should limit the number of work site accesses and entry points as much as possible. Such considerations help to minimise disruptions, delays and potential incidents to traffic in the surrounding road network.

• High Speed Roads

Locating the work site accesses along high speed roads can pose challenges to construction vehicles as they:

- Take a longer time to pick up speed when entering the roadway due to the equipment or loads they carry.
- Require some distance to slow down and a wider turning radius in order to turn into the work site safely.

The example below shows the provision of a lay-by with acceleration lane on a major arterial road (70km/hr). The lay-by arrangement provides construction vehicle with some space and distance to pick-up speed in order to merge safely with the main road traffic. The contractor has also adopted the use of low height hoarding to provide drivers of construction vehicles leaving the work site with a good view of approaching vehicles and vice versa.



Figure 1: Lay-by with acceleration lane

• Restricted Operation Hours

At heavily trafficked and high speed roads (e.g. major arterial roads, expressways), the use of worksite accesses should be restricted to off-peak periods to minimise potential conflicts that can lead to possible traffic congestion and road incidents.

• Position Of Work Access Along The Road

The work site access location should be carefully considered, with good line of sight such that motorists have adequate time to react to movements of construction vehicles at these areas. Particular attention should be given to situations at the following locations.

Areas with high pedestrian movements



Figure 2: Site access arrangement at high pedestrian movements area

Conflicts should be minimised at areas with high pedestrian movements (CBD, shopping areas, schools etc). The photograph above shows an example of a site access/egress located near an area with high pedestrian movements during peak periods. To minimise conflicts, the contractor has introduced several goods practices:

- The full height hoardings located close to the work site access have been replaced with low height type to enhance visibility so that pedestrians and construction vehicles are able to see each other near the entrance and egress.
- A speed regulating hump has been installed just at egress to encourage construction vehicles to reduce speed at this area.
- Trained traffic controllers are positioned at the work site access/egress to regulate the movement of pedestrians and construction vehicles during operation hours.

High traffic conflict points

- Work site accesses should be relocated away from the main road to side/minor roads whenever possible.
- Avoid locating the work site access along road sections with higher conflict points (e.g. at junctions, lane merging locations, exit of bus bays, tight curves etc).
- These areas increase the likelihood of incidents/accidents as drivers may fail to cope with the increased driving demands.

SAFETY CONSIDERATIONS FOR CONSTRUCTION SITE ACCESS

Providing good line of sight of the work site access

The driving task is visual in nature, requiring motorists to see, analyse the situation and to react accordingly. The location of worksite access should therefore be easily distinguished by motorists travelling on the roadway and not catch them by surprise. Work site access should be located away from these areas as they might not be obvious to motorists:

- Downstream on the inside of the horizontal bend
- Downstream after the crest of a vertical curve
- Near a junction



Figure 3: Poor site access arrangement near junction

The picture shows a work site access located next to a junction. The arrangement could catch motorists by surprise especially when construction vehicles suddenly slowed down after turning into the minor road. The better option would have been to relocate the work site early in the design state. To mitigate the risk, the contractor has installed measures such as advance warning signs along the main road to alert motorists of the location of the site access.

OTHER CONSIDERATIONS

• End Treatment Of Safety Barriers

Where breaks are created along the hoarding lines due to the presence of work site access, it is important to provide proper treatments to any safety barriers that have been installed along these locations.

The next example below shows the contractor implementing proper treatments to the approaching ends of the safety barrier near a work site access. The ramp down end treatment would protect any run-off vehicles from hitting the exposed ends of the safety barriers. Being a low speed road, the ends of the VIG has been ramped down in accordance with the design standard.



Figure 4: Proper end treatment of VIG

• Lateral Clearance Of "Work Access Ahead" Warning signs

"Work Access Ahead" signs needs to be positioned with at least 0.6m lateral clearance from the edge of traffic lane so that they do not protrude out onto the carriageway.



Figure 5: Adequate lateral clearance from carriageway

In the example above, the contractor has located the sign above the hoarding line and 0.6m from the road edge (given the tight corridor for the construction works). Nearer the entrance, lower height hoardings should have been installed to alert motorists to the presence of the work site access.

• Unique Arrangements - Bifurcation Of Road



Figure 6: Bifurcation challenges in the arrangement of site access

"Bifurcations" are sometimes introduced as part of a road diversion scheme in tight corridors with space constraints. For the example shown, safe usage required the designer and construction team working together to not only developing a safe design but also to implement additional operation controls for vehicle movements. With the work being carried out on the expressway, strict controls were introduced and construction vehicles were only permitted to enter/leave the work site during specific hours during the off-peak periods. The slow lane was also closed during these periods to allow the safe movements of construction vehicles.

CONCLUSION

Designing work zone in Singapore continues to be challenging because of our urbanised environment and limited space. Nevertheless, designers and contractors have demonstrated that a good design is possible and safe work site access can be provided. Designers and contractors need to continue to learn from best practices, employing sound engineering judgement, and give careful consideration to the needs of road users and construction traffic. In this way, safety of the work zone would be enhanced and road users would enjoy a pleasant journey.

Alvin Soong

Manager, Road System Safety
Safety Division

INTRODUCTION

The scope of Contract 151A (C151A) comprises of the supply of 22 new trains for the existing North-South Line (NSL) and East-West Line (EWL). The contract was awarded to Kawasaki/CSR Sifang Consortium in May 2009 and the first 5 trains entered revenue service in May 2011.



Figure 1: C151A Train

The trains are designed by Kawasaki Heavy Industries (KHI) of Japan. Carbody manufacturing, train assembly and testing are conducted by China Southern Railway (CSR) Sifang in Qingdao, China.

A thorough suite of tests was conducted to ensure that the trains perform safely as designed. This article highlights how the key safety features of the C151A trains were tested before the trains were proven fit for service.

SUB-SYSTEM TYPE TEST

A train comprises various sub-systems such as air-conditioning, propulsion and brake systems etc. Before the commencement of manufacturing, all sub-systems are type tested¹. Subsequently, each unit of the sub-system is subjected to routine tests² before being assembled into a train.

• Brake Shoe Material Test



Figure 2: Dynamometer and brake blocks used in dynamometer test

In terms of safety, the train brake system is one of the most critical sub-systems for safe operation as it enables a train to stop within a safe stopping distance

One key component which has significant impact on brake performance is the brake shoe. To validate the choice of

brake shoe material for the C151A trains, a dynamometer test was carried out at the test facility of the brake supplier, Knorr-Bremse, in Germany.

The test simulated the interaction between the train wheel and brake block under operating conditions of train run profiles, such as the real route profile of NSL and EWL. By repeating the same series of run profiles using different brake blocks, an assessment of the most optimal choice of brake block material was completed.

• Carbody Shell Strength Test

As the main load carrying structure of the train, the carbody shell is designed to withstand exceptional loading conditions without sustaining permanent deformation and fracture, and at the same time, achieving the required service life under normal operating conditions.

The first completed carbody shell was subjected to a series of compression and tension tests under various loading conditions before mass production. During the test, all measured stresses were within the material yield stress limits. It proved that the design of carbody shell manufactured could meet the design requirements.



Figure 3: Crashworthiness Test

COMPLETED-TRAIN TYPE TEST & ROUTINE TEST

Upon full assembly of the train, the entire train was subjected to further testing. Extensive train type tests and routine tests were conducted in CSR Sifang's factory before delivery to Singapore. This allowed quick rectification of engineering issues at the factory where specialist manpower and material resources are readily available.

Upon delivery to Bishan Depot, the train was subjected to another round of testing including system functional tests, train performance test and integrated and interface tests to ensure that the train is able to operate as designed on the depot test track first before undergoing testing on the mainline.

LTA staff witnessed all the tests to ensure that tests are conducted in accordance to approved test procedures and the train could perform to meet the specifications.

The following tests are some of the safety-related tests which were carried out in China or Singapore.

¹ "Type Tests" refers to tests designed to prove that systems can perform to meet the required design specification.

² "Routine Tests" refers to tests to check for correct manufacturing and proper functionality.

TESTING OF SAFETY FEATURES FOR C151A TRAINS

• Saloon Doors Function Type Test

Saloon door testing is to ensure that an obstacle of 20mm by 40mm size can be detected when placed between closing doors. The obstacle is placed at a height of 1m above the floor to simulate obstruction by passenger or their belongings when the doors are closing. When an obstruction is detected, an alarm signal would be sent to the driver, the door's indicator lights would flash and train movement would be inhibited.



Figure 4: Obstacle detection



Figure 5: Push-back force measurement

For smaller obstacles (i.e. clothing), each door has a 'push-back' feature which allows the saloon doors to be opened by up to 100mm (50mm per leaf) for any small obstacles trapped to be retrieved when the door is closed. A functional test was conducted to verify that this feature could be achieved within the push-back force specified in the door design.

• Passenger Detrainment Type Test

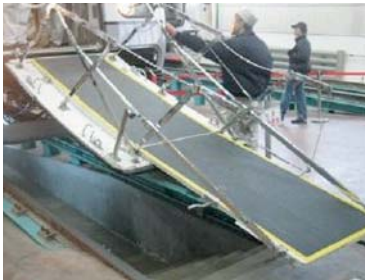


Figure 6: Emergency Detrainment Door Deployment Test

Both the plug door and the folding ramp of the detrainment door were tested to operate safely.

The Emergency Door Detraining Time test demonstrated that the time taken to deploy the detrainment door ramp and to evacuate a full load train of approximately 1600 passengers is not more than 30 minutes.



Figure 7: Emergency Detrainment Test

• Passenger Emergency Communication (PEC) Test

The PEC unit provides a means of bi-directional inter-communication between passengers and the train driver during emergency.

There are four (4) PEC units in each car and these are located on the door pillars. The push button of the PEC units was tested to ensure its functionality. When any of the PEC push buttons is pressed, an audible buzzer alarm and the 'Passenger Alarm' indicator light would be triggered in the cab.



Figure 8: PEC and Alarm Reset Key

A moving train with an activated PEC would proceed and stop at the next station.

The train would be held there until the activated PEC unit is reset with an Alarm Reset Key carried by the train driver.

• Fire and Smoke Detection Test

To test the sensitivity of smoke detection, a specific chemical mist dispensed from an aerosol can was sprayed at the detector to simulate smoke. Use of the chemical allows the test to be carried out safely without the need to ignite a fire, which is hazardous and may damage the train.

If a fire develops inside the saloon, an alarm for internal fire would be triggered. The exhaust air dampers would open and the return air dampers close, expelling smoke from the train interior.

Should smoke be detected in the fresh air inlet, which would indicate an external fire, the fresh air dampers will close to prevent smoke entering the saloon area.

• Emergency Operation Test

In the event of a failed train on the mainline between two stations, which has to be recovered, a test to demonstrate that this operation could be carried out was conducted. A rescue train is coupled to the immobilized defective train to provide traction and to move it to the nearest station for passengers to evacuate. Thereafter, the rescue train would continue to either push or haul the defective train back to the nearest depot.

The C151A train propulsion system had been tested and proven to be adequately rated for this operation.

• Mainline Running Test

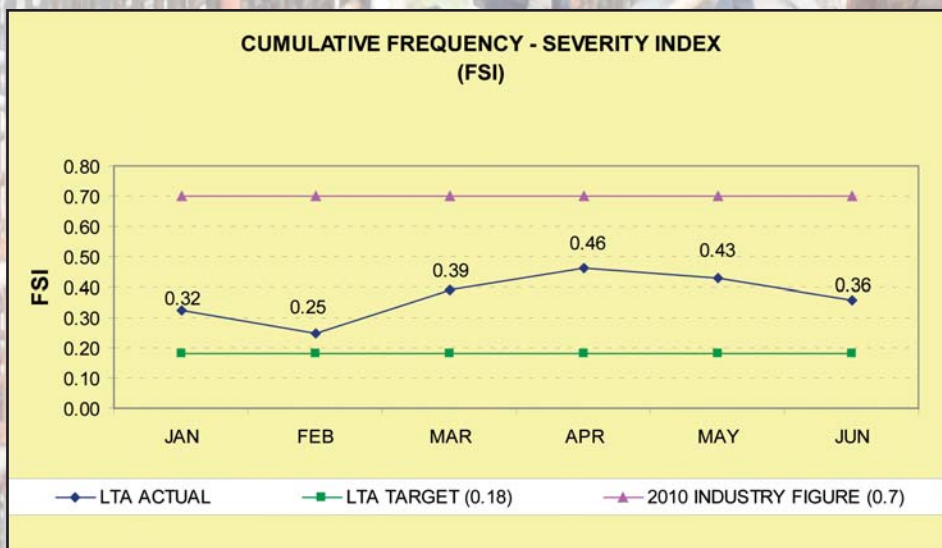
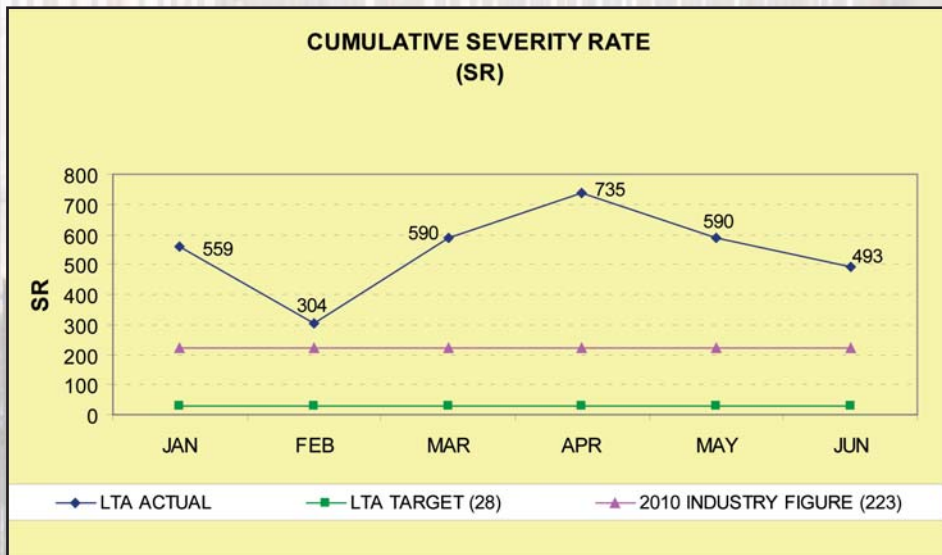
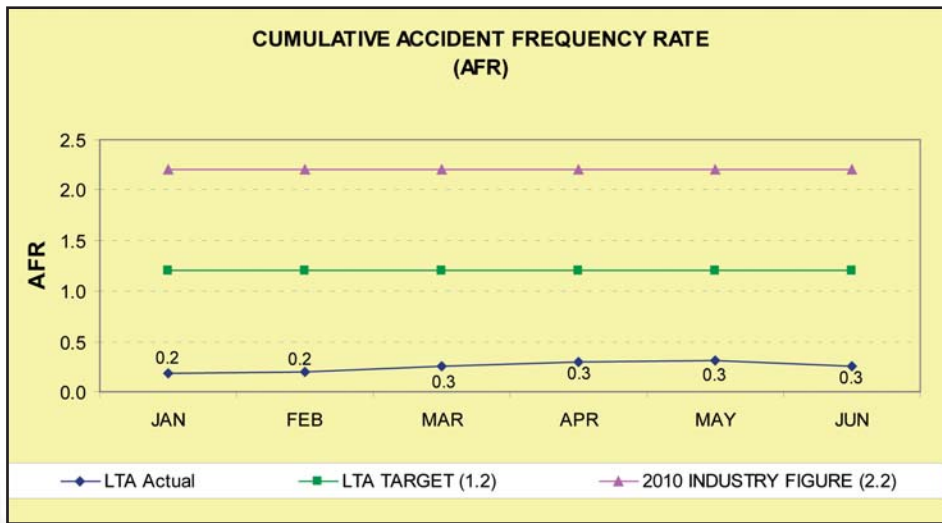
Finally, a combined test was jointly conducted between C151A and system-wide contractors on NSL and EWL to ensure smooth operation of trains on the existing system.

CONCLUSION

Comprehensive tests were carried out to ensure all the safety related features of C151A trains and the whole train system could function properly. By passing all the safety tests mentioned in this article, C151A trains would operate safely on the existing NSL and EWL.

Wen Jie
Engineer, Rolling Stock

2011 Accident Statistics*



* Based on Singapore Workplace Safety and Health Act Requirements

ASEAN Dengue Day 2011

On 15 June 2011, Singapore commemorated the first ASEAN Dengue Day. The ASEAN Dengue Day is an annual advocacy campaign day for dengue prevention and control at the regional and national level.

In support of this inaugural ASEAN Dengue Day, LTA and its contractors have carried out a 1-hour carpet combing exercise across all LTA construction sites throughout the month of June. LTA and its contractors have also pledged their commitment and continually strive to keep worksites dengue-free.



DTL2(CT1) contractors and LTA representatives pledging their support in the fight against dengue.



Carpet combing exercises aimed at eradicating potential breeding grounds were carried out at LTA construction sites

LTA Contractors' Safety Forum 2011

More than 170 staff and contractors' representative attended the first LTA Contractors' Safety Forum on 15 April 2011 at the HSO auditorium. The safety forum served as an excellent platform for sharing of recent serious incidents and accidents that have happened at our worksites. It is also to engage our contractors and to work in-hand with them in ensuring high level of safety controls and compliances for the delivery of our projects.



Workplace Safety and Health (WSH) Act Update

The Workplace Safety and Health (WSH) Act will cover all workplaces from September 2011. Under this Act, employers must manage risks at work while employees must adhere to safe work practices. The WSH Council has also prepared a starter kit to help individuals and organisations fulfil their obligations under the Act.

For more information on your roles and responsibilities, please visit www.wshc.sg

Safety Phoa says...

To have a sustainable safety culture, we must inculcate good safety behaviour in our organisation. The Behavioural Based Safety (BBS) program is one such program that our contractors can use to influence their workers.



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