

# **Executive Summary**

## **TRA's Train No. 408 at Qingshui Tunnel**

On April 2, 2021, at approximately 0928, the Taroko Express train No. 408 of the Taiwan Railways Administration (TRA) departed from Shulin Station to Taitung Station. The train consisted of eight cars and carried 498 persons, including 2 train drivers, a train conductor, a janitor, and 494 passengers, was traveling along the east main line from Heren Station to Chongde Station. At mileage K51+450.1, the train exited the south end of Heren tunnel and struck a heavy truck that had stopped on the track after sliding down the slope from a construction access path above the track. The collision caused all eight cars of the train to derail. Car 8 (the leading car) to Car 3 were all stuck in the Qingshui Tunnel. The left side of Car 8 collided against the entrance of the Qingshui Tunnel and was damaged. Car 7 was disconnected from Car 6, and Car 6 to Car 4 were crushed and deformed. This accident resulted in the death of 49 persons, including 2 train drivers and 47 passengers, and the injury of 213 persons, including a janitor and 212 passengers.

The accident site was between south of Heren Tunnel and north of Qingshui Tunnel. Prior to the accident, TRA was implementing 「Slope Safety Improvement and Protective Facility Program」 which is included a 125m steel reinforced concrete open-cut tunnel to prevent rocks from falling onto the west main line track. During the construction, TRA dispatched its staff to monitor the rockfall site but withdraw them at end of March 2021. Dong Xin Construction Ltd., (hereinafter referred to as Dong Xin Construction) was responsible for the construction and C.Y.L Engineering Consulting INC. (hereinafter referred to as C.Y.L Engineering) was responsible for project management, as well as United Geotech INC.

(hereinafter referred to as United Geotech) was responsible for design and supervision. The TRA requested all divisions to suspend all construction during the Tomb Sweeping Holiday period from April 1, 2021, at 1200 to April 6, 2021, at 1200 and finished the inspection of the construction site by United Geotech.

At approximately 0800 on the day of the accident, the worksite director and migrant worker of Dong Xin Construction drove a truck to the platform above the open-cut tunnel and arranged four rebar workers working inside the open-cut tunnel. At 0912:44, the truck stopped at a slope due to the worksite director's improper operation, the truck stalled and failed to restart the engine due to the low battery. In order to jump-start the truck with the battery of the excavator, the worksite director tied one end of the webbing sling to the truck's left column and tied the other end to the bucket of the excavator, and attempted to pull the truck to a proper location. At approximately 0927:05, the webbing sling slid off from the bucket of the excavator, the truck slid along the construction access path and rolled off the slope as well as landed on the center of the east main line at K51+450.1, a distance of 252.1 m from the south end of Heren Tunnel. The worksite director neither carried the TRA's radio nor had an emergency phone number, he failed to notify the TRA operation control center in Taipei, Heren and Chongde Stations near the construction site, and the drivers of the adjacent trains to stop the train instantly.

At 0928:27, the leading car exited the south end of the Heren Tunnel with a speed of 126 km/h. According to the eye tracker test, the train driver was affected by visual adaptation (1.18 seconds) and the curve of the track after exiting the Heren Tunnel. Based on the test, the train driver might see the truck on the track at 0928:32. According to the record of Train Control Management System (TCMS) of the occurrence train, the train driver activated the emergency brake before 0928:33 and according to the

interview, the passengers heard a long train horn prior to the collision. At 0928:34, the occurrence train was traveling at 123 km/h and tilted left after it collided against the truck on the railway track. The front of Car 8 crashed against the left wall of the north end of Qingshui Tunnel, and the left side of the cab at Car 8 was torn off. The front door and some parts of the exterior of the train were left outside the north end of the Qingshui Tunnel. The train moved in the tunnel for 130 m before it finally stopped.

In accordance with the Transportation Occurrences Investigation Act, Taiwan Transportation Safety Board (TTSB) established an investigation team to investigate the occurrence. The agencies (institutions) invited to participate in the investigation included the Ministry of Transportation and Communications (MOTC), Railway Bureau, TRA, Directorate General of Highways, Public Construction Commission, Construction and Planning Agency of Ministry of the Interior, Occupational Safety and Health Administration of Ministry of the Labor, Hualien County Government, C.Y.L Engineering Consulting INC (hereinafter referred to as C.Y.L Engineering), United Geotech INC (hereinafter referred to as United Geotech), Dong Xin Construction Ltd. (hereinafter referred to as Dong Xin Construction), and Hotai Connected Co., Ltd.

This investigation report details TRA's construction risk assessment, construction safety management and public construction procurement system, etc. The contents include: the operation and contingency handling of the occurrence truck, train driver's braking handling, expediting pressure of the construction, safety equipment and facilities for adjacent track construction, safety management and inspection for adjacent track construction, survival factors, quality management of TRA's manual, railway train event recorder and necessary record parameters, construction and government construction procurement system and implementation,

and clearly define the responsibilities of government unit, etc.

The investigation report was published on May 10 after being approved by the 38th Board Committee Meeting on May 6, 2022.

On the basis of comprehensive factual information and analyses, TTSB proposes the following 47 findings and 16 recommendations:

## **Findings**

### **Findings Related to Probable Causes**

1. On the day of the accident, the worksite director and migrant worker of Dong Xin Construction violated restrictions that prohibited working during the holiday period and entered the construction site to place scrap tires. The worksite director drove the truck away from the platform above the west main line open-cut tunnel afterward. When turning left and traveling down the construction access path along the east main line, the worksite director did not properly control the clutch pedal and the accelerator pedal which caused the truck to stall. The truck had a faulty battery and could not be restarted. Consequently, the truck was stuck on the slope of the construction access path.
2. The worksite director did not contact vehicle maintenance workers for assistance but tried to jump-start the truck by connecting the batteries of the two vehicles. The worksite director asked the migrant worker to drive the excavator at the construction site to the left side of the truck. The worksite director then used a webbing sling to link the bucket of the excavator with the truck's left column and tried to pull the truck to a proper location by the excavator due to the limited length of the jumper cable, however, the webbing sling on the bucket of the excavator was not properly secured. Besides, neither the worksite director nor the migrant worker was licensed technicians of excavators.
3. The webbing sling was not secured and fell off the bucket at

approximately 0927:05, disrupting the initial static equilibrium between the load of the webbing sling and the weight of the truck. The grade of the construction access path was 12.6 degrees and the surface was covered in earth and sand. Consequently, the friction between the wheels of the truck and the slope was not enough to stop the truck from sliding. Moreover, the construction access path did not have any safety barriers. Consequently, the truck slid along the construction access path and fell off the slope onto the east main line track.

4. The worksite director was not carrying the handheld wireless train radio provided by the TRA Hualien construction section staff and was unable to contact the driver of the train, the station staff on duty, or the dispatcher of the general dispatch office by using the emergency call button of the radio and make the train slow down or stop.
5. At approximately 0928:27, the occurrence train was traveling at 126 km/h along the east main line, which was slower than the speed limit of 130 km/h. The train exited the south end of Heren Tunnel and the driver was affected by visual light adaptation for approximately 1.18 sec. In addition, the tracks of the accident site were curved and obstacles were not expected on the track ahead. Consequently, the driver might have seen the truck lying on the track at approximately 5.46 sec after the train exited Heren Tunnel and applied the emergency brake at 6 sec. However, the train was still traveling at 123 km/h when it collided with the truck, 1 sec after the emergency brake was applied.

### **Findings Related to Risk**

1. On the day of the accident, Dong Xin Construction did not dispatch any personnel to guard the entrance of the construction site. Even if they did, the personnel probably would not have been able to prevent workers from violating restrictions and entering the construction site

since the personnel was employed by Dong Xin Construction.

2. Although Dong Xin Construction had a gate at the entrance of the construction site, the gate lock was broken. The supervising company did not follow the rule to require the contractor to improve their access control equipment.
3. The TRA did not specify the installation of access control equipment or the operating procedures of security personnel.
4. The TRA did not require daily working notification from the contractor and was not able to manage the status of construction sites or construction workers along tracks, increasing operational safety risks.
5. The contract between the TRA and the supervising company did neither specify that personnel must stay at the construction site 24 hours a day nor that personnel should inspect construction sites during holiday periods when the construction is suspended. On the day of the accident, the supervising company did not send any personnel to inspect the construction site as usual during holiday periods.
6. Prior to the accident, due to the construction method and labor shortage problems, the bracing construction of the west main line open-cut tunnel was behind schedule. This could be the reason that Dong Xin Construction sent four construction workers to the west main line track near the overhead line to reinforce steel bars during the holiday period without power outage or track possession.
7. Prior to the accident, the bracing construction protocol of the open-cut tunnel was changed from daytime construction to nighttime construction due to safety concerns. Consequently, the time available for daily construction was cut in half. TRA allowed the contractor to delay the expected completion date to some extent and requested more construction workers, resulting in pressure to expedite the construction.

8. United Geotech did not follow the safety regulations of TRA and instead designated the bracing construction of the open-cut tunnel as daytime construction. The project management company C.Y.L Engineering and TRA did not notice that the designated construction time violated safety regulations when they reviewed the design diagram.
9. The TRA did not specify the conditions requiring power outage or track possession during the construction near railway tracks. Consequently, the contractor and the supervising company did not have a consistent standard for the safety protective measures required for train operations.
10. The TRA provided construction safety education training to the workers of contractors through meetings rather than training courses. No training material was provided, had little training time, no evaluation system, and the contractors can provide safety training to their workers themselves. Consequently, the workers were unaware of the risks of construction near railway tracks when they worked. The four rebar workers and one migrant worker had never received construction safety education training prior to the day of the accident.
11. Prior to the construction project, TRA and the project management company as well as the engineering design company all evaluated the construction site and failed to notice the risk that vehicles on the construction access path could slide off the slope. During the construction, two accidents involving construction vehicles occurred, and the occupational safety and health personnel of the contractor suggested the installation of safety barriers. However, the worksite director of the contractor refused the suggestion because the safety barriers were not in the design from the engineering design company, and budget was not allocated for construction safety.

12. The TRA lacked an effective detective system to detect and alert hazards that might affect train operation at tunnel entrances or slopes of cutting. In addition, the TRA did not provide adequate safety and protective measures for train operation and did not meet the requirements of the Regulations for the Construction and Maintenance of Railways published by the Ministry of Transportation and Communications.
13. The Ministry of Transportation and Communications did not include regulations of the International Union of Railways and barrier design suggestions from the United States Federal Railroad Administration in regulations for the design of tunnels. These regulations could include the installation of protective equipment such as guide walls or guard rails to prevent the front of the train from directly colliding against the tunnel wall and severely damaging the train in the event of a derailment.
14. Without altering the design, the contractor used Portland cement concrete instead of asphalt concrete as design to pave the construction access path on the slope. In addition, the construction access path was covered by earth and sand on the day of the accident, and vehicles could easily slip. The Ministry of Transportation and Communications, the Construction Quality Supervision Task Force of the TRA, the Occupational Safety and Health Office of the TRA, the Department of Construction of the TRA, and supervising company United Geotech inspected and reviewed the construction site five times within a year before the accident but no deficiencies related to the surface of the construction access path were reported.
15. The Ministry of Transportation and Communications and the TRA mainly inspected the construction progress and construction quality. In terms of safety, they only focused on the safety of the workers and did



not comprehensively evaluate other risks that could endanger train operations.

16. The TRA did not provide sufficient education training to TRA personnel responsible for construction contracts. Consequently, such personnel were unable to review and approve the safety items of construction projects; the review procedures did not work as intended.
17. The TRA did not formulate management and review standards for personnel transfer in important positions such as worksite directors, which is not conducive to assessing whether personnel is suitable for the position before the transfer.
18. The TRA did neither specify regulations regarding the handheld wireless train radio provided to the contractor for emergency notification nor training that should be conducted. Consequently, TRA personnel lent the handheld wireless train radio to the worksite director and he did not utilize the emergency notification function of the train radio.
19. The TRA did not stipulate that the emergency reporting sign should clearly list the contact information of units such as the nearest train control room and the general dispatch office which have the authority to stop trains. The TRA also did not require construction workers to carry the emergency contact information card at all times, causing failure to send emergency notifications.
20. The construction plan of the contractor did not specify the emergency notification procedures to the nearest train control room or the general dispatch office if construction affects the safety of train operations. The procedures were reviewed by the supervising company and project management company as well as TRA, all of them failed to notice this deficiency.
21. The fatal rate of passengers with standing tickets was seven times

higher than that of passengers with seated tickets. The TRA policy of 120 standing tickets for each Taroko Express or Puyuma Express train did not comprehensively consider the safety performance indicator in the event of collision or derailment as well as the comprehensiveness and effectiveness of risk management measures.

22. The train-related technical specifications published by the Ministry of Transportation and Communications did not include international standards such as European standard EN15227 which specifies the crashworthiness of trains and provides a standard for the procurement of trains for railway operators and the approval for operation by supervision agencies.
23. A total of 10 deceased passengers with standing tickets were standing in gangway connections between carriages, accounting for 71.42% of all deceased passengers with known standing locations and accounting for 20.4% of all deceased passengers. Therefore, the proportion of deceased passengers who stood in gangway connections was high. The train-related technical specifications published by the Ministry of Transportation and Communications and TRA did not define a crumple zone in the carriages. In addition, the TRA did not effectively warn or limit passengers' stay in gangway connections or compartments, which are crumple zones.
24. The passenger safety and emergency response information provided by the TRA on its official website and in its trains was incomplete and may have caused passengers to incorrectly assess the hazards on the site after an accident occurred or be unaware of the location and usage of safety equipment.
25. The safety equipment on the Taroko Express train did not include a handheld megaphone or automated external defibrillator. In addition, the train conductor had to manually activate the emergency ventilation

system, and the passengers could not contact the train conductor with the intercom system when the train conductor left the train conductor compartment. These factors could all affect the performance of emergency response. The train-related technical specifications published by the Ministry of Transportation and Communications also did not specify the safety equipment required to respond to emergencies in tilting trains, and railway operators did not have a standard to follow.

26. The train conductor of the occurrence train did not fully understand the design and usage of the safety equipment of the Taroko Express; such equipment included emergency lighting and ventilation and could have affected the survival chances of passengers. The TRA train conductor crew manual did not include technical information such as the quantity, function, and location of safety equipment, therefore, train conductors had difficulty familiarizing themselves with the safety equipment on the train.
27. The TRA conducted the train conductor training with mentoring programs, which could neither guarantee the provision of knowledge on the systems and equipment of different types of trains nor guarantee that all the train conductors had consistent performance after the training.
28. In response to the train conductor skill evaluation required by law, the TRA only provided training rather than skill test. The training did not include the technical skills items required by law and could not guarantee that train conductors were familiar with the required skills when they were on duty.
29. The TRA poorly managed the quality of the train conductor crew manual and the maintenance manuals as well as the operation manuals of the Taroko Express. TRA personnel had difficulty confirming the

effectiveness of the manuals and acquiring effective versions of the manuals.

30. The TRA did not install event data recorders that comply with international standards. In addition, the TRA did not actively use the safety data provided by the event data recorders to develop quality assurance, monitor potential risks, and improve train operation safety.
31. The Ministry of Transportation and Communications did not specify regulations regarding the installation, essential parameters, and crash resistance of event data recorders in trains, therefore, the railway operators did not have a regulation to follow.
32. The worksite director of Dong Xin Construction was also the responsible person of another construction company, which violated the Construction Industry Act. In addition, the Construction Management Information System owned by the Construction and Planning Agency of the Ministry of the Interior was not interfaced with other systems such as the Building Management Information System, the Public Construction Management Information System of the Public Construction Commission, or the Company Registration Inquiry System of the Department of Commerce, therefore, owners and project management companies, as well as supervising companies, had difficulties reviewing the qualifications of worksite directors.
33. The Government Procurement Act and the Construction Industry Act prohibit the lending and borrowing of licenses to tender for contracts. However, the laws failed to effectively prohibit the lending and borrowing of licenses in practice.
34. The Railway Bureau was mainly responsible for the construction of the railway, and only a small proportion of its human resources and budget were allocated to the supervising of railway safety; these factors are unfavorable for the professional supervising of railway

safety. In addition, the TRA was also responsible for the maintenance work of the railway; in addition, the division of labor between the TRA and the track construction of the Railway Bureau was ambiguous and unfavorable for specialized operations.

### **Other findings**

1. The construction access path above the east main line had warning tape around it. The warning tape was placed to warn personnel from coming near the slope of the construction access path but could not prevent personnel or vehicles from falling off the slope. Because the construction access path was on a slope instead of a flat surface, therefore, only follow the rule “warning tape is required to indicate construction more than 3.0 m away from the railway track” specified in the Special Regulations for Train Operation Safety cannot ensure the safety of train operation.
2. A year before the accident, the TRA sent an operation telegram and requested the suspension of construction work during holiday periods to avoid disrupting train operations. The TRA also sent another notification prior to the accident to remove the speed restriction of slow speed sections back to the original operation speed limit.
3. The north end of the Qingshui Tunnel complied with the dimensions specified in the TRA railway construction procedures.
4. Car 8 to Car 5 were seriously damaged and accounted for 82.1% of all wounded and deceased passengers.
5. A total of 27 deceased passengers were in Car 8 and the gangway connection between Car 8 and Car 7, accounting for 55.1% of all deceased passengers. The death rate of passengers with standing tickets was 24.6%, which was notably higher than the death rate of passengers with seated tickets 3.49%.

6. The front of Car 8 collided against the truck while traveling at high speed, then tilted left and crashed against the wall at the entrance of the tunnel, causing severe extrusion and damage on the front and left side of Car 8, and the extrusion as well as deformation of the gangway connection between Car 8 and Car 7. Consequently, most deceased passengers were in Car 8 and the gangway connection between Car 8 and Car 7.
7. The construction company owned by the worksite director, Yi Cheng Construction Co., was convicted of forging construction photos and daily reports in 2018. However, the Hualien County Government responsible for the construction did not active the procedure to suspend Yi Cheng Construction Co.'s right to tender for contracts due to doubts about whether it met the suspension standard of the Government Procurement Law. Consequently, the Government e-Procurement System of the Public Construction Commission did not blacklist the company and Yi Cheng Construction Co. was still able to tender for public construction contracts.
8. The responsible person of the company blacklisted on the Government e-Procurement System can still tender for construction contracts through his/her other companies. The quality of public construction could be secured and the professionals could be chosen if the construction agency can review the full history of a tenderer's construction quality, suspension records, and related companies owned by the same responsible person through a well-developed construction resume system.

## **Safety Recommendations**

### **To the TRA**

1. To increase the safety of train operations, the TRA should specify the safety management regulations and implementation mechanisms for construction near railway tracks. In addition, the TRA should include the regulations in instruction to tenderers and contracts. The regulations should address the following:
  - (1) Principles for risk identification and evaluation before construction.
  - (2) Definitions of the construction conditions required power outage, track possession, and set up corollary equipment and procedures.
  - (3) Definitions of the construction region, which should include all areas that might be affected by the construction.
  - (4) Requirement of a daily working notification.
  - (5) Implementation of access control measures and equipment. (excluding construction manufacturers) .
  - (6) Specification of the frequency of construction site inspections and the number of supervising company personnel required for the inspection.
  - (7) Correction and review of near-miss events.
  - (8) Establishment of emergency notification procedures, provide contractors the handheld wireless train radio with training, and provision of publishing and applying emergency contact information.
  - (9) Installation of track invasion active detection equipment and provision of guidance about adequate protective measures for construction projects that could endanger the safety of train operations.

(10) Provision of safety training by TRA directly to construction workers.

2. Establish a change management system, which clearly stipulates that hazard identification, appropriate risk assessment, and control measures must be carried out before changes in personnel operations, engineering technology, and organizational personnel.
3. Provide comprehensive training related to how construction affects the safety of train operations to TRA contract case officers and reviewers to improve their capability to audit and review contracts.
4. Reexamine the extending calculation of the construction duration to avoid companies ignoring construction safety due to the expedition of construction and cost-related factors.
5. Refer to international standards and consider specifying buffer zones in trains, such as the aisles and gangway connections. The TRA should reevaluate and limit the standing ticket regions, set up warning signs, and improve the management of train conductors.
6. Review and improve the passenger safety information on the TRA official website and in trains, ensure it includes the information needed for emergency response of passengers and the operation of safety equipment in the event of an accident.
7. Review and improve the safety equipment in different types of trains, documents for safety equipment required to be used by train conductors, and the method of train conductor training and skill evaluation to improve the performance and effectiveness of emergency responses.
8. Improve the quality of the operation manual, the maintenance manual, and the train conductor crew manual to ensure that the content of the manuals is effective and relevant personnel can obtain a valid version.
9. Evaluate and install event data recorders that comply with international



recommended standards, and actively use the safety data in the data recorders to improve train operation safety.

### **To the Ministry of Transportation and Communications**

1. Reexamine organizational specialization to ensure that units are specialized in railway safety supervision, railway construction, and railway operations, and clearly define the responsibilities between units.

### **To the Railway Bureau**

1. Refer to international railway safety regulations or studies, revise supervising regulations, and include safety standards or recommended measures, such as invasion active detection system, requiring a tunnel protective measures( guide wall or guide rail ), defining crumple zones, and placing warning signs at such zones, labeling the safety equipment required for emergency responses in the train, and listing the essential parameters and crash resistance of the event data recorder.
2. Review and improve the inspection system of the training and skill evaluation of train crew to ensure that the railway operators are enforcing such training and evaluation.

### **To the Construction and Planning Agency**

1. Improve the Construction Management Information System by interfacing with the Building Management Information System, the Public Construction Management Information System, and the Company Registration Inquiry System, and adding a cross-check function that can actively provide warnings. Therefore, owners, project management companies, and supervising companies can review the qualifications of worksite directors more easily.

### **To the Public Construction Commission**

1. Work with the departments concerned, review and reinforce to disseminate the effective measures that prevent companies from lending and borrowing licenses.
2. Based on the current government procurement gazette system, reinforce to disseminate the criteria for suspending blacklisted companies and the mechanism of in-time reporting.
3. Optimize and reinforce to disseminate the construction resume data to assist the government agencies in selecting the outstanding companies and professionals in tendering public construction.

Note: The language used in occurrence investigation Final Report is in Chinese. To provide general understanding of this investigation for non-Chinese reader, the Executive Summary of the Final Report was translated into English. Although efforts are made to translate it as accurate as possible, discrepancies may occur. In this case the Chinese version will be the official version.