For Information
June 2016

Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Latest update on issues relating to train of the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link

Purpose

This paper provides the latest situation on issues relating to train of the Hong Kong section ("HKS") of the Guangzhou- Shenzhen-Hong Kong Express Rail Link ("XRL").

Background

2. In January 2010, the Government entrusted the MTR Corporation Limited ("MTRCL") with the construction and trial operation of the HKS of the XRL. Safeguarding railway operational safety is of the top priority of the XRL project. For years, MTRCL has been adopting a comprehensive project and operation management system by making use of System Assurance and System Integration to achieve the high standard in quality and safety, which covers the design, construction, production, testing and operational management of the XRL. The Government attaches great importance to the safety of the XRL. Since commencement of the project, the Government has been monitoring the construction progress of the entire project at different levels, including train safety. The Government and the MTRCL reported the safety management measures for trains of the XRL, the safety standard and signalling system adopted in meeting of the Subcommittee on Matters Relating to Railways of the Legislative Council Panel on Transport on 4 July 2014. The relevant paper is attached at Annex 1.

3. The MTRCL's update on the latest development of the trains of the XRL is attached at Annex 2.

Train Design and Procurement

4. Regulation of railway safety in Hong Kong is all along based on the standards of advanced countries, including the United Kingdom, Germany, France, Japan etc. Since XRL trains will not only run in Hong Kong but will also connect to the national high speed rail networks, XRL trains must therefore comply with the national railway safety regulations established by the National Railway Administration ("NRA") of the People's Republic of China and other technical requirements of the national high speed rail as well.

5. According to the Entrustment Agreement, the MTRCL is responsible for the design and construction of the XRL project. Based on information provided by the MTRCL, they adopt a comprehensive management system in project management and operation in reviewing the design, construction, production, testing and operation arrangement to achieve the high standard in quality and safety. Regarding the tendering of the XRL works, the Highways Department ("HyD") would send representatives to join the tender procurement meetings and monitor the procurement process of the XRL to check for compliance with the relevant procedural requirements. However, HyD did not participate in the tender assessment.

6. Prior to the commissioning of the XRL, the MTRCL is required to submit detailed information to the HyD, the Electrical and Mechanical Services Department ("EMSD") and other relevant Government departments to demonstrate that when the train is operating in actual conditions, its safety performance can achieve the safety level of comparable international standards.

7. The nine sets of CRH380A train procured under the XRL project has to comply with the EN12663 standard, which is a standard that specifies structural requirements for design

of railway vehicles covering the structural strength of the entire train body. EN12663 requires manufacturers to consider requirements such as maximum loads and required service life to confirm that the structural strength of train body is sufficient to meet operational needs.

Active Train Protection Design for Train Safety

8. The HKS of the XRL adopts a passenger dedicated line design, i.e. no mixed operation with freight trains, and the entire line is constructed inside tunnels without any level crossing with highways. Therefore, collision between train and car, freight train or large obstacle will not happen.

9. It is more important to prevent the occurrence of train incidents than to reduce casualties after the occurrence of incidents. The safety of modern railway primarily relies on signalling system protection. The concept of "Active Safety Protection" has been widely adopted in high speed railways. The XRL also adopts this concept and is equipped with a signalling system which regulates through real time detection of various data such as trains location and respective speed etc. in order to maintain safety distance between trains to prevent collision. The signalling system is also equipped with Automatic Train Protection functions, which will issue deceleration command to train drivers in case of speeding or the distance from the preceding train is too close. Emergency brake will be applied when necessary. In addition, modern signalling system is designed in accordance with "fail-safe" principle under which the train will be automatically stopped if there was fault in railway equipment or system so as to avoid collision and protect train safety.

10. To achieve seamless integration with the Mainland high speed rail network and to protect operational safety, the signalling system of the HKS of the XRL has adopted the Chinese Train Control System [1] ("CTCS") specifications.

[1] CTCS standard is equivalent with the European Train Control System, which has three classes. The HKS of XRL would be operated under CTCS-3 signalling system under normal situation. If there is malfunction in the CTCS-3 signalling system, the train control would be switched to CTCS2 signalling system automatically to maintain train services.

The XRL adopts CTCS Level 3 system as well as the CTCS Level 2 system. The multi-layer and redundant backup systems will provide the railway with multiple protections. The CTCS is designed in accordance with “fail-safe” principle. The reliability of CTCS is very high, where the probability of the failure of both CTCS Level 3 and 2 systems at the same time is very remote. In an extreme case that the multi-layer and redundant backup systems all fail, the Operation Control Centre would verify the safety of the railway before authorising drivers to manually operate trains of sight driving and at restricted speed in accordance with the emergency procedures. This arrangement is compliance with the national railway safety standard established by the NRA and the industry practice.

International Safety Level

11. EN15227 standard which is of concern to the public is developed based on the unique environment and operation modes of railways in Europe. The operation modes of Europe railways involve railway tracks unprotected by any signalling system or need to be shared use by passenger and freight trains. EN15227 standard provides a passive safety requirement on trains for cases of collision under slow speed where provision of active safety measures is insufficient.

12. Although EN15227 standard is not applicable to Hong Kong and Mainland high speed railways, to allay public concerns, the MTRCL has sought clarification with the European Committee for Standardization (“CEN”), which is responsible for developing European Union (“EU”) standards. CEN subsequently confirmed that for railway operation organisations outside the EU, they could conduct risk assessment based on actual operating conditions in accordance with Annex A of EN15227 and develop corresponding safety measures according to the result of the risk assessment.

13. The HyD and the EMSD has completed reviewing the Collision Risk Assessment Report submitted by the MTRCL, and agreed that the MTRCL had taken reasonably practicable safety protection measure to prevent high speed train collision

in accordance with the practice of international railway industry. The HyD and the EMSD also noted that the MTRCL has employed an independent consultant to verity that the Active Safety Protection and associated risk management of the trains were in compliance with EN15227 standard and the risk had been reduced to acceptable level.

14. In addition to the Collision Risk Assessment Report, the MTRCL engaged the manufacturer of the CRH380A trains procured by the MTRCL to perform Train Collision Analysis which verified that the MTRCL's CRH380A trains could withstand a collision at 25 km per hour under the collision scenario mentioned in EN15227 standard. The EMSD, the MTRCL and the train manufacturer separately engaged independent consultants to review the Train Collision Analysis Report. All of the independent consultants agreed that the CRH380A trains procured by the MTRCL could withstand a collision at 25 km per hour under the collision scenario mentioned in EN15227 standard.

High Speed Trains Quality

15. Regarding the featuring of media reports alleging that abnormal cracks are found on the CRH380A trains operated by the Guangzhou Railway Corporation, in response to the enquiry made by the MTRCL in 2014 and this year, the train manufacturer has denied such allegation. The EMSD has also put up enquiries separately to NRA and the train manufacturer. The train manufacturer replied and denied such allegation. EMSD is waiting for NRA's response.

16. The first CRH380A train procured by the MTRCL will be delivered to HK in the second half of this year. The MTRCL would resemble the train at the Shek Kong Stabling Sidings for subsequent check, static test, low speed test and acceptance inspection. Prior to the commissioning of the XRL, new trains have to pass three types of testing, including Factory Acceptance Test, System Integration Test and On-site Test, to confirm that the trains meet the required international safety level. During the testing, the EMSD and relevant

departments will assign staff to monitor the tests to confirm that they are properly carried out.

17. Safeguarding railway operational safety of the XRL is of the top priority of the Government. According to information provided by the MTRCL, they adopted a comprehensive management system in project management and operation to review the design, construction, production, welding, testing process and operation arrangement, to ensure high standard of quality and safety. For the manufacturing of trains, the MTRCL has engaged an independent safety expert to perform independent safety assessments on systems that are critical to train safety (including trains and signalling systems). Relevant Government departments and the MTRCL would perform inspections and tests in accordance with the stringent requirement as usual to protect the operational safety of the XRL.

Transport and Housing Bureau
Highways Department
Electrical and Mechanical Services Department
June 2016

For discussion
on 4 July 2014

Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Safety Management Measures for Trains of
Guangzhou-Shenzhen-Hong Kong Express Rail Link

Purpose

This paper sets out the safety management measures for trains of the Guangzhou-Shenzhen-Hong Kong Express Rail Link.

Background

2. In January 2010, the Government entrusted MTR Corporation Limited (MTRCL) with the construction of the Hong Kong section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL). The Government attaches great importance to the safety of the XRL. Since commencement of the project works, the Government has been monitoring the construction progress of the entire project at different levels, including train safety. Information on the safety standards and signaling systems of the Hong Kong section of the XRL adopted by MTRCL is set out at the **Annex**.

Train Design

3. Regulation of railway safety in Hong Kong is all along based on the standards of advanced countries, including United Kingdom, Germany, France, Japan etc. MTRCL is required to submit detailed information to the Electrical and Mechanical Services Department (EMSD) to demonstrate that when the train is operating in actual conditions, its safety performance can achieve the safety level of comparable international standards. Since XRL trains will not only run

in Hong Kong but will also operate in the national high speed rail networks, XRL trains must therefore comply with the national railway safety regulations established by the National Railway Administration of the People's Republic of China as well.

4. The trains of the Hong Kong section of the XRL (CRH380A) Hong Kong section of the XRL adopt EN12663 standard which specifies structural requirements for design of railway vehicles covering the structural strength of the entire train body. EN12663 has been widely used for high speed trains throughout the world. EN12663 requires manufacturers to consider factors such as maximum loads and required service life to ensure that the structural strength of train body is sufficient to meet operational needs.

5. EN15227 standard mainly covers the safety requirements for trains under different collision scenarios. Amongst others, the structural strength of train body must withstand the impact at collision speed of 36 kilometres per hour to minimise the possible injuries that may cause to all people on board. This standard is developed based on the operation modes of railways in Europe. The operation modes of European railways involve railway networks connecting different countries, railway tracks shared use by passenger and freight trains, level crossings at intersection of railway track and other vehicular road, and even railway sections unprotected by any signalling system. According to our understanding, at the time when the international open tendering of the Hong Kong section of the XRL was conducted by MTRCL, all of the tenderers indicated that none of the existing high speed train models could meet the requirements of EN15227 standard.

6. EN15227 standard allows individual railway to conduct risk assessment based on its actual operation conditions and possible collision scenarios, so as to decide what train protection measures are required. This is a practical approach and in line with the spirit of EN15227 standard.

Safety Management Measures for XRL Trains

7. The Hong Kong section of the XRL is totally different from

European railways in that it has adopted passenger dedicated line design, i.e. no mixed operation with freight trains, and the entire line is constructed inside tunnels without any level crossing with highways, thus ensuring situations of collision between train and car, freight train or large obstacle will not happen.

8. It is more important to prevent the occurrence of train incidents than to reduce casualties after the occurrence of incidents. Therefore, "Active Safety Protection" measures are more effective than "Passive Safety Protection" measures. This concept has been adopted by most countries. The safety of modern railway primarily relies on **signalling system protection** to ensure a safe distance between trains being maintained to avoid collision. This is especially important in the design of high speed railway as it would be very difficult for any train design to protect people on board in the event of train collision at high speed.

9. The Hong Kong section of the XRL has adopted Chinese Train Control System (CTCS)[Note] specifications for active protection, including CTCS-3 specification and CTCS-2 specification as multiple back-up systems designed to provide multiple failure defense to ensure operation safety. The design principle of CTCS signalling system is a "fail-safe design", i.e. the train will automatically stop to ensure safety if the system fails.

10. Upon the featuring of media reports earlier this year alleging that the XRL trains were not able to comply with EN15227 standard, the Railways Branch of EMSD has immediately followed up with MTRCL and requested it to clarify with the European Committee for Standardisation (CEN), which is responsible for developing European Union standards, on whether the use of risk assessment is in line with the spirit of EN15227 standard. CEN subsequently confirmed that the use of risk assessment results to develop corresponding safety measures complies with the spirit of EN15227 standard.

[Note] CTCS is the Chinese Train Control System with specifications similar to that of the European Train Control System. The System consists of three levels, of which Level 3 is the most advanced level providing the highest train operation frequency. Under normal operation, the Hong Kong section of the XRL will adopt CTCS-3 signalling system. When CTCS-3 signalling system fails, it will automatically switch to CTCS-2 system for maintaining services.

11. In the light of media report claiming that the Chinese manufactured CRH3 high speed train could meet EN15227 standard, which MTRCL asserted otherwise, EMSD has sent staff to visit the National Railway Administration of the People's Republic of China, China Railway Corporation and the three Mainland high speed train manufacturers (including the successful tenderer CSR Qingdao Sifang Co. Ltd., CNR Changchun Railway Vehicles Co. Ltd. and Tangshan Railway Vehicle Co. Ltd.) in April and May 2014 and discuss with the staff of these organisations to understand the safety design of Mainland high speed trains. Having confirmed with the concerned organisations, none of these three manufacturers had adopted EN15227 standard for production of high speed trains, including the CRH3 high speed train.

12. EMSD has also checked with the high speed train manufacturers in France, Germany and Japan to ascertain whether their trains are in compliance with EN15227 standard. According to replies received, only the Velaro D high speed trains of Siemens, which were put into operation in 2013, is able to meet the requirements. The maximum speed of Velaro D is 320 kilometres per hour, which falls short of the maximum speed of 350 kilometres per hour for XRL trains.

13. The probability of CTCS-3 and CTCS-2 signalling systems failing simultaneously is rare. Even under such situation, the operation of the high speed trains will be automatically suspended by the system. The Operations Control Centre in Shek Kong must follow strict codes of practice in allowing train drivers to operate line of sight driving at slow speed to maintain limited services under safe conditions.

14. MTRCL has conducted risk assessment based on the guidelines of EN15227 standard. EMSD has received the risk assessment report and a train collision analysis report submitted by MTRCL, and is now vetting these reports in detail. EMSD has also requested MTRCL to appoint an independent consultant to review the train collision analysis report prepared by the train manufacturer, so as to prove the safety performance of the train at different collision speeds. MTRCL has actively cooperated with EMSD, and EMSD is awaiting MTRCL to submit the required review report. EMSD has urged MTRCL to

establish the future train operation and management modes (including an appropriate line of sight driving speed), based on the actual operating conditions in Hong Kong as soon as possible, in order to prove that the XRL train can achieve a safety level equivalent to that of EN15227 standard in actual operation, and to submit the details to EMSD for approval.

15. Prior to the opening of the Hong Kong section of the XRL, new trains have to pass three types of testing, including Factory Acceptance Test, System Integration Test and On-site Test, to ensure that they meet the required international safety level. The Highways Department and EMSD will assign staff to witness the conduction of the tests to ensure that they are properly carried out.

Transport and Housing Bureau
Electrical and Mechanical Services Department
July 2014

Annex

Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Safety Management Measures for the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link Trains

INTRODUCTION

This paper serves to provide to the Legislative Council Panel on Transport Subcommittee on Matters Relating to Railways relevant information about the safety management measures for the Hong Kong Section of the Guangzhou-Shenzhen-Hong Kong Express Rail Link ("XRL") trains, and to provide a brief description on how the trains and signaling system work together to ensure safe operation of the XRL.

BACKGROUND

2. The MTR Corporation Limited ("the Corporation") is entrusted by the Government on the construction of the XRL, including the procurement of high-speed trains.

3. Safeguarding railway operational safety is of the top priority of the Corporation in managing the XRL project.

4. Procurement of the XRL rolling stock follows a consistent open, fair and impartial procedure and also complies with the stringent requirements of the WTO Government Procurement Agreement. Representatives from the Highways Department also participated in the procurement process.

5. Nine high-speed trains have been procured for the XRL project. All trains procured must comply with the relevant technical and functional requirements prescribed in the contract. The train structural requirements of the newly ordered high-speed trains comply with

European Union's EN12663 standard, a European Standard which has been widely adopted worldwide in high-speed trains, covering the structural strength and resilience of the carbody.

6. The contract was awarded to CSR Qindgao Sifang Co., Ltd. through an international open tendering process.

TRAIN SAFETY STANDARDS

7. All the XRL trains are required to meet the relevant international safety standards, including EN12663 standard for the design of carbody structure.

8. EN12663 is a widely adopted international standard for the design of the carbody of railway vehicles introduced by the European Union (EU). The standard states that the structural requirements shall be assessed based on the following criteria: (a) maximum loading consistent with normal operational requirements; and (b) to achieve the required service life. The standard also mentions the need to incorporate appropriate safety margin when considering the design parameters to allow for possible uncertainties, such as loads, material (processes, time/ageing, operating environment, etc.), manufacturing processes and analytical accuracy, to provide structural integrity to the occupied areas in a collision-type accident.

9. EN12663 describe the requirements for demonstration of carbody strength and structural stability, stiffness and fatigue strength that the carbody structure design shall achieved. For example, for demonstration of carbody strength and structural stability, the standard stipulate that it shall be demonstrated by calculation and/or by testing, that no significant permanent deformation or fracture of the structure as a whole / of any individual element / of any equipment attachment, will occur under the prescribed design load cases.

10. The standard defined detailed requirements for the design load cases, including longitudinal loads for vehicle body (compressive force at buffers, compressive force below buffer, compressive force applied

diagonally at buffer attachment and tensile force at coupler attachment), vertical loads (maximum operating load when lifting and jacking up the train), all kinds of proof loads at interface (such as body to bogie connection, equipment attachments and joints of articulated units), general fatigue load cases for the vehicle carbody, fatigue loads at interface as well as the vibration modes.

11. EN15227 standard for train crashworthiness was published in 2008 to address the safety framework specific for the railway operating environment in Europe for light rail system, sub-urban trains as well as high-speed rail. This standard is compatible with the requirements of EN12663. Whilst EN 12663 stipulating requirements for the structural integrity to the occupied areas in a collision-type accident, EN15227 sets **additional passive safety requirements for structure** to address the specific railway operating environment in Europe. EN15227 define the following categories of railway vehicles: coaches and mixed train units; metro vehicles; tram trains and peri-urban tram; and tramway vehicles. In addition, the following design collision scenarios were defined for each category of vehicle: (a) collision of identical train unit; (b) collision with wagon/mixed traffic regional train; (c) collision with 15 tons deformable obstacle or 3 tons rigid obstacle; and (d) collision with small low obstacle. According to these vehicle types and these 4 possible collision scenarios, EN15227 provide for the design of the carbody structure to comply with the passive safety requirements, including overriding height; survival space and deceleration limit/collision pulse. Based upon each categorisation of railway vehicles and the 4 collision scenarios, it is considered that EN15227 provide for the cases **where provision of proactive safety measures**, such as the automatic train protection system by signaling, **is not available** or railway with mixed mode operation or with level crossing. In case of a collision, passive safety measures shall be provided in railway vehicle design to enhance the safety of occupants inside the train. The carbody structure requirement for train crashworthiness at 36km/h specified in EN15227 is only for slow driving conditions, not a protection for collision in high speed.

12. EU's EN15227 standard is mainly for the environment and unique operation conditions in Europe (with some of the lines without any protection by signaling system or in share use of tracks with other road

vehicles), where a passive rather than a proactive train safety protection measure is adopted to reduce the impact from collision with another train to the minimum. Various scenarios are defined mainly based on the environment in EU countries, while railway institutions may, according to local requirements and scenarios, to develop specific solutions for implementation. According to the handling solutions recommended in the Annex A of EN15227, railway institutions may (a) make reference to relevant local regulations and/ or (b) to proceed with a risk assessment.

13. When the international open tendering process for the XRL trains started in 2011, the Corporation did note that the EN15227 standard began publishing in Europe. However, there was no mature high-speed train model design based on this standard nor one that met the requirements of this standard at that time. Considering that the EN15227 standard is more relevant to the operation mode in EU, including operations in different countries, share use of tracks by passenger and freight services, junction with road vehicles as well as no signal system protection in some sections, which has relatively higher operational risks. This is entirely different from the high-speed rail system in Hong Kong and the Mainland which operates entirely on dedicated tracks and tunnels. Having assessed the future operation requirements and technical risks, the Corporation considered adopting the existing mature product is more suitable and less risky than asking suppliers to develop a new high-speed train model. It is understood that the existing trains operating in the Mainland, including CRH3 model, are not designed and produced in accordance with EN15227 standard. The Corporation contacted manufacturers in the Mainland and China Railway Corporation again in mid-2014 for updates, but the same message was conveyed that the national system in the Mainland is different to those in Europe in terms of dedicated lines, protection by multiple layers of signaling system, etc., thus EN15227 is not applicable; while all CRH train models, including CRH3, have not adopted this standard.

14. Dedicated lines and high level of proactive protection are adopted by the high-speed rail in Hong Kong and the Mainland, which is different from the unique environment and operation modes in Europe (with some of the lines without any protection by signaling system or have to share tracks with road vehicles). The XRL trains will not only be running

within Hong Kong, but also connecting with the National High-speed Rail network. The XRL trains comply with international safety standards as well as the Mainland railway safety requirements set by the National Railway Administration.

15. The safety management system of the MTR operation system is in compliance with requirements in EN50126[1] (Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)). With reference to the operating characteristics and system configurations of the XRL (including proactive and passive safety equipments and measures), a collision risk assessment on train had been carried out. A review by independent safety advisor had also been conducted to confirm that the existing system is up to relevant safety standards. The concerned review report has been submitted to relevant government departments for review.

16. In fact, high level of proactive protection and strictly regulated operation have been adopted in Hong Kong and the Mainland to control operational risk, compliance with the principles and handling solutions under EN15227 standard.

17. In terms of the coupler, the same model as that for CRH3, namely "European Type 10" has been adopted for XRL trains which is equipped with anti-climb design features including preventing overriding and energy absorption devices. The Corporation has been supervising closely the design and manufacturing process; and has adopted monitoring measures and Independent Safety Assessment process at the above project stages to ensure the trains being designed and built will be in compliance with international safety standards and Mainland railway safety requirements.

[1] The European Standard EN50126 provides the railway industry with comprehensive management process which will enable the implementation of reliability, availability, maintainability and safety. The approach defined in this standard is consistent with the application of quality management requirements contained within the ISO 9000 series of international standards.

SAFETY PROTECTION FUNCTION OF THE SIGNALING SYSTEM

18. In addition to the structural integrity of the train carbody, protection by the signaling system plays an even more important role in railway operational safety for the high-speed rail. The signaling system regulates safety distance between trains to prevent collision.

19. The XRL is equipped with a comprehensive signaling system. The signaling system regulates through real time detection of trains location and respective speed in order to ensure safety distance are maintained between trains. The signaling system is also equipped with automatic train protection functions, which will issue deceleration command to train drivers in case of speeding or distance from the former train too closed. Emergency brake will be applied when necessary. To ensure safety, 'fail-safe' principle is adopted for the design of signaling system with XRL to automatically stop the train in case of system/equipment failure or system errors.

20. The XRL is a comprehensive and integrated system consisted of dedicated route, train, signaling system and other relevant components. To achieve seamless integration with the Mainland high-speed rail network and to ensure operational safety, the signaling system of the Hong Kong section of the XRL shall comply with the Mainland's, i.e. the CTCS (Chinese Train Control System) specifications which is set with reference to the ETCS (European Train Control System) specifications. Both specifications have the similar safety requirements. The XRL (including HK section) adopts CTCS-3 system (equivalent to ETCS-2) with communications-based train control specifications, as well as the track circuits-based train control CTCS-2 system (equivalent to ETCS-1) specifications. The multi-layer and redundant backup systems adopt independent and different technology on transmission mode, controlling principles as well as independent trainborne and trackside signaling equipment which will provide the railway with multiple protections. The function of the signaling system is to ensure the safety distance is maintained between trains. The safety record and standard of high-speed railway systems adopting proactive protection mode, including Japan are extremely good.

21. To ensure a high level of reliability and safety of the high-speed rail services and most importantly, the integration with other railway systems for the high-speed rail operation, integration test and related drills will be conducted during the pre-opening period to ensure it will meet and operate to the stringent safety and performance requirements. In extreme cases that manual operation is required, the emergency procedures will include restricted speed operations to ensure adequate safety distance are provided between trains to prevent collision.

TESTING BEFORE OPERATION

22. Testing to be conducted at the Guangzhou-Shenzhen section, during non-operation hours, is to confirm that the XRL trains are compatible for running in this section. The remaining tests can be carried out in the Hong Kong section. The arrangement for the testing at the Guangzhou-Shenzhen section is currently managed by China Academy of Railway Sciences for the coordination with the Guangzhou Railway (Group) Corporation.

23. Before trains are delivered to Hong Kong, they will be arranged to complete type-tests at the manufacturer's factory and the Mainland section to ensure relevant requirements stipulated in the contract and for the national high-speed trains were fulfilled. The design of the XRL trains is similar to trains operating in the Mainland. Upon completion of the required tests in the Mainland, the trains are expected to be recognised in principle by relevant Mainland administration and able to run in the National High-speed Rail Network. This could shorten the required testing period for the Guangzhou-Shenzhen section.

CONCLUSION

24. Six to nine months for the integrated testing and related drills and exercises on the Guangzhou-Shenzhen-Hong Kong section has been reserved before XRL opening which is considered sufficient to ensure overall train reliability and railway safety.

25. Electrical and Mechanical Services Department (EMSD) will thoroughly assess all testing reports submitted by the Corporation, and participate in on-site tests to ascertain relevant guidelines have fulfilled before the XRL trains are approved for service. Upon passenger service, EMSD will continue to monitor XRL railway operations to ensure its safety performance is in compliance with international standards. The Corporation will provide full support to jointly safeguard railway safety.

MTR Corporation Limited
July 2014

Annex 2

Legislative Council Panel on Transport
Subcommittee on Matters Relating to Railways

Latest updates on the Hong Kong section of the
Guangzhou-Shenzhen-Hong Kong Express Rail Link Trains

INTRODUCTION

This paper serves to provide the Legislative Council Panel on Transport Subcommittee on Matters Relating to Railways ("RSC") with updated information on trains for the Hong Kong Section of Guangzhou-Shenzhen-Hong Kong Express Rail Link ("XRL").

BACKGROUND

2. At the RSC meeting held on 4 July 2014, MTR Corporation Limited ("the Corporation") and the Electrical and Mechanical Services Department ("EMSD") explained in detail the design and safety management measures for the XRL trains, and relevant information of the train and signaling system was also submitted (LegCo paper reference "CB(1)1722/13-14(05)").

3. Safeguarding railway operational safety has always been the highest priority for the XRL project. To ensure design, construction, manufacturing and testing processes as well as the operational arrangements to meet high quality and safety requirements, a comprehensive project and operational management system has been established over the years using the System Assurance and System Integration approaches.

4. The XRL adopts an integrated safety system comprising dedicated passenger lines, rolling stock, signaling system and other related components. Stringent safety standards have been enforced throughout the train design and manufacturing processes, etc.

5. During the XRL trains procurement carried out by the Corporation, manufacturers were required to comply with international standards and fulfil relevant technical and functional requirements as prescribed in the contract. For instance, the structural design of the XRL trains complies with the European Union's EN12663 standard, which is a mature and

comprehensive international safety standard. The EN12663 standard, which covers the structural strength and resilience of the carbody, is widely adopted by high-speed trains worldwide.

6. In addition, the safety management system of the XRL is in compliance with international standards and provides a comprehensive railway management process, thus will enable the implementation of reliability, availability, maintainability and safety of service; and is also consistent with practice codes of the international railway industry.

PROACTIVE SAFETY MEASURES

7. The National High-speed Rail Network (including the Hong Kong section of the XRL) adopts proactive protection design with an effective signaling system to regulate the safe separation distance between trains through real time detection of train locations and respective speeds to prevent collision. The signaling system is equipped with Automatic Train Protection ("ATP") function which will issue a deceleration command to the train driver in case of speeding or being too close to the preceding train and, when necessary, even halt train movements. To prevent collisions and ensure safety, the 'fail-safe' principle is adopted for the design of the signaling system to stop trains automatically in case any signaling failures or errors occur.

8. The high-speed rail system in Hong Kong and the Mainland adopts a dedicated passenger lines approach, deploys high standards of proactive protection design and strictly regulates operating procedures to control operational risks. To achieve seamless integration with the Mainland high-speed rail network and to ensure operational safety, the signaling system of the Hong Kong section of the XRL shall comply with the Mainland's, i.e. Chinese Train Control System ("CTCS") specifications, which are set with reference to the specifications of the European Train Control System ("ETCS"). Both specifications have similar safety requirements. The multi-layered and redundant backup designs offered by the CTCS-3 system, with communications-based train control specifications, and the CTCS-2 system, with track circuit-based train control specifications, have been adopted for the XRL (including the Hong Kong section). These two systems comprise independent and different technologies on transmission mode, controlling principle as well as independent trainborne and trackside signaling equipment designed to provide the railway with multiple protections and ensure safety. CTCS-3 or CTCS-2 has two sets of systems respectively. Both sets of CTCS-3

system operate simultaneously; if one set fails, the other one could still function normally. If both sets of CTCS-3 system were to fail, the CTCS-2 system will start operation. In the same way as the CTCS-3 system, CTCS-2 is equipped with two sets of systems, whereby if one set failed, the other one could still operate normally.

9. In addition to the dual protection provided by the CTCS-3 and CTCS-2 systems, an Operation Control Centre ("OCC") to deploy XRL trains within the Hong Kong section has been located at Shek Kong Stabling Sidings ("SSS"), to maintain a high level of reliability in the XRL signaling system. The OCC in Hong Kong will independently monitor and control trains running within its jurisdiction through strict operational procedures. If necessary, when the multi-layered signaling system failed and the OCC has ensured that the section ahead has not been occupied by any trains, train drivers could be authorized to switch to On-Sight mode and restricted train speed in a safe operating environment to deliver passengers to the next section safely. This arrangement follows national railway safety regulations established by the National Railway Administration of the People's Republic of China and the industry practice.

INTERNATIONAL SAFETY LEVEL AND SAFETY STANDARDS

10. The EN15227 standard (train crashworthiness), which was the subject of some public concern earlier, is mainly provided for the unique railway environment and operational conditions in Europe where, for example, some of the lines are not operated under any protection of signaling systems and/or sharing the use of path with other road vehicles. In these circumstances, adequate proactive safety measures are not in place and therefore passive measures are adopted to increase safety from collision under various low-speed operational scenarios. The National High-speed Rail, which adopts a high level of proactive protection design and strict operations regulations in controlling train operational risks, is totally different from the operating environment in Europe.

11. Though it is deemed unnecessary for the high-speed rail system in Hong Kong and the Mainland to adopt EN15227 standard, the Corporation understands public concerns on XRL's operational safety. To allay these concerns, the Corporation sought clarification and received confirmation from the European Committee for Standardization ("CEN") that railway institutions operating outside of the European Union ("EU") can regulate corresponding

safety measures in accordance with their actual operating conditions and risk assessments under different possible collision scenarios as suggested by the handling procedures prescribed in Appendix A (Parameters of Design Collision Scenarios) of EN15227 standard.

12. The Corporation carried out a Collision Risk Assessment according to the handling procedures prescribed in Appendix A of EN15227 standard. The report has been reviewed by an independent safety advisor and it was confirmed that the collision risk for the XRL trains has been reduced to acceptable level. EMSD has reviewed the Report and agreed that the Corporation has adopted reasonable and practicable safety measures which comply with international railway practice to prevent train collisions.

TRAIN COLLISION PERFORMANCE TEST

13. As mentioned in the RSC meeting held in July 2014 when addressing Members' questions, the structural strength of the carbody of the XRL trains, which were procured for the XRL project, was reported to be able to withstand an impact at collision speed of around 25 km per hour (kph), which was a preliminary estimate. To further verify the safe collision speed, the Corporation subsequently arranged with the train manufacturer to conduct additional laboratory tests and clarify technical details.

14. The information on laboratory tests and train collision analysis, submitted by the train manufacturer in accordance with the testing requirements prescribed in EN15227 standard, confirmed the safety performance of the XRL train at low-speed collisions. The Corporation appointed an independent consultant to review the Report and has made appropriate enhancements to the train as recommended by the independent consultant. It also confirmed that the XRL train could withstand a collision at 25 kph as per the scenarios prescribed in EN15227 standard.

15. EMSD, with assistance from its independent consultant, reviewed the Train Collision Analysis Report and agreed with the analysis of train collision simulation and findings. To facilitate Members and the public a better understanding of the analysis on simulated train collisions, an executive summary of the related report is attached as **<u>Annex</u>**.

16. The Corporation would like to reiterate that proactive protection design is the first and vital measures for railway safety. To ensure railway operational

safety, the XRL system adopts a high standard of proactive protection designs together with stringent operational procedures. Under an extremely rare situation when train movement is authorized to manual operation under On-sight mode and restricted train speed, stringent operating procedures and multiple safety measures will be applied to ensure operational safety, these include the confirmation of no other trains are in the same operation section ahead and train will be operated under restricted speed.

MEDIA REPORTS OF CRACKS FOUND IN MAINLAND HIGH-SPEED RAIL TRAINS

17. In response to rumours and media reports on irregular cracks found on CRH380A high-speed rail trains in the Mainland and the discard or re-deployment of trains, the Corporation had approached train manufacturer in 2014 and this year and was informed that all these reports were unfounded. Regarding the "irregular ringlike crack" featured in media coverage, information from the manufacturer showed that the concerned area is the interface of the aluminum alloy carbody and glass-reinforced plastic front-end cover, where surface coating paint cracking might occasionally occur due to thermal expansion and contraction. However, trains safety and railway operations would not be affected.

18. According to the information acquired by the Corporation, the CRH380A for the Wuhan-Guangzhou High-speed Railway, including 19 sets and 66 sets of CRH380A trains under the management of Guangzhou Railway (Group) Corporation and Wuhan Railway Administration respectively, are operating as usual. The China Railway has deployed a number of trains that were previously managed by the Guangzhou Railway (Group) Corporation to the Shanghai Railway Administration for use; however those trains were neither CRH380A model nor were there any cracks found on these trains. As at May 2016, approximately 373 sets of CRH380A trains, about 40% of the total high-speed trains under the 350kph category, have been in service for more than 468 million kilometres in the Mainland and none of these are founded with irregular cracks on the train bodies.

19. Stringent safety standards were followed throughout the train design and production by the Corporation. To ensure international safety standards and national regulations are followed in material and production quality, the manufacturing process is closely monitored by designated staff stationed at the factory; while monitoring measures and independent expert assessments are

also implemented at different stages of the process. For instance, all welding works were carried out by professionally trained and certified welders in accordance with specified procedures and standards. Finished works were checked by inspectors to ensure the quality is up to standard.

TRAIN DELIEVERY AND PRE-OPERATION ARRANGEMENT

20. It is expected that the first XRL train, CRH380A model procured for the XRL project, will be delivered to Hong Kong later this year. The structural works and E&M installation at SSS have been completed. The track areas at the SSS Running Maintenance Shed have been energized and are ready for train testing. Assembly, verification, static tests, low speed tests and acceptance tests will be carried out at SSS upon train arrival.

21. The Corporation and relevant government departments will carry out integrated testing, drills and exercises to ensure overall reliability and operational safety before commencement of train service.

CONCLUSIONS

22. The XRL trains, CRH380A model procured for the XRL project, comply with EN12663 standard, which is widely adopted by high-speed trains worldwide for the design of carbody structure in structural strength and resilience of the carbody. The maximum loading in corresponding to the operational requirements and required service life spam are defined in the standard. It also describes the requirements for demonstration of static strength and structural stability, stiffness and fatigue strength that the carbody structure design shall achieve to cope with operational needs.

23. EN15227 standard is provided for the unique operational environment in Europe where signaling protection is not provided in all the railway lines. However, XRL adopts dedicated passenger lines with a comprehensive signaling system for proactive safety protection, hence, EN15227 standard is deemed unnecessary. To ease public concerns, the Corporation carried out a risk assessment in accordance with Appendix A of EN15227 standard after clarifying with CEN. The assessment confirmed that collision risk for the XRL trains has been reduced to an acceptable level.

24. In addition to proactive protection designs, the Corporation also made

reference to the experience gained from railway operations to formulate XRL's safety management measures, including stringent operating practices and procedures in deploying trains, in reducing operational risks to the minimal level in accordance with international safety standards. Prior to the commissioning of XRL services, the Corporation will seek the required approval from EMSD and relevant government departments. EMSD and relevant government departments will continue to monitor the services throughout the future operations to ensure the safety standards and performance are commensurate with international standards.

MTR Corporation Limited
June 2016

Executive Summary

on

Train Collision Analysis for CRH380A Trains Procured for Guangzhou-Shenzhen-Hong Kong Express Rail Link (Hong Kong Section)

Introduction

A comprehensive assessment, based on the method described in the European standard EN 15227, was carried out to confirm that the CRH380A trains procured for the Hong Kong section of Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL) would be able to meet below acceptance criteria as set out in EN 15227 at a collision speed of 25km/h:

Item	Acceptance Criteria
Overriding	Wheel lift-off distance up to 100mm
Survival Space	Passenger area: Reduction in length to be no more than 50mm over any 5m length
	Driving cab area: Clearance in front of the driver seat to be no less than 300mm
Deceleration Limit	Less than 5g (g = acceleration due to gravity)

Methodology of Assessment

The method set out in the EN 15227 standard can be breakdown into 4 major parts which are outlined in the flow chart in Figure 1. Details description of the work for each part is provided in later sections.

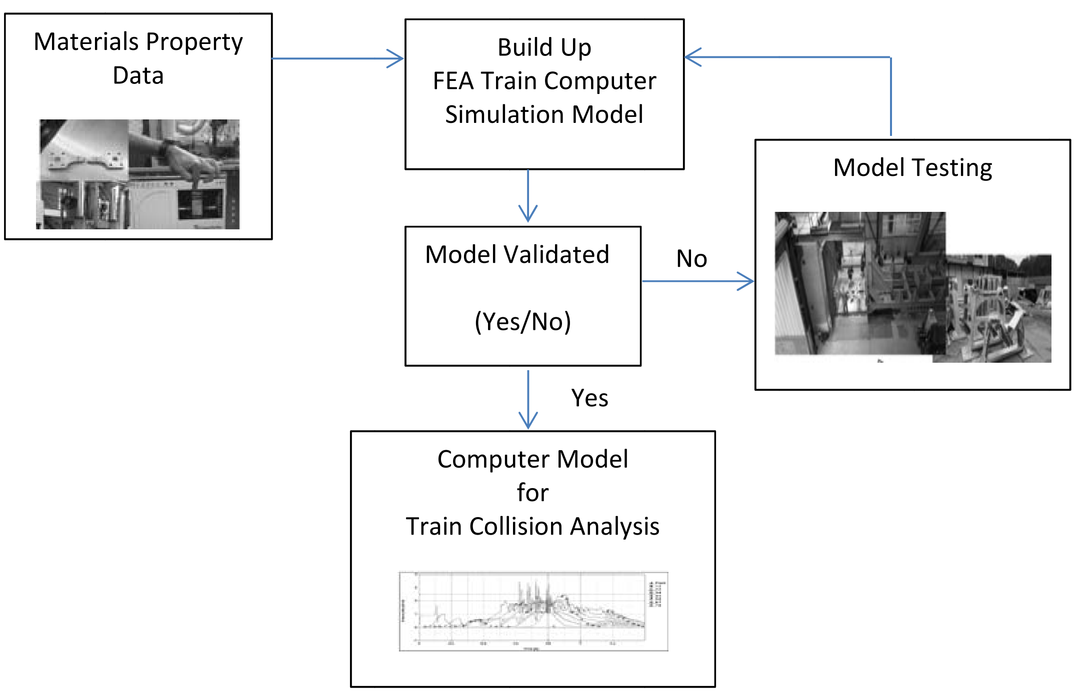


Figure 1: Methodology of Assessment

CRRC Sifang Co., Ltd. (Sifang), the train manufacturer of the CRH380A model procured for the Hong Kong section of the XRL, had enlisted the services of H.C Engineering & Technology Co., Ltd., specialist Germen consultant in vehicle structural design and crashworthiness in carrying out the vehicle crash analysis, built up FEA train model and preparation of the report.

In addition to material property data from supplier, a German applied research laboratory – Fraunhofer Institute for Mechanics of Materials was engaged by Sifang to carry out tests for crash properties of the aluminium materials of the carbody. This will ensure the material data used under different deformations and damages conditions is accurately characterised and having been validated by a world renowned organisation.

Construction of Finite Elements Analysis (FEA) Vehicle Model

The XRL train, CRH380A model procured for the Hong Kong section of the XRL, consisted of 8 cars with a driving cab car at each end as shown in Figure 2 below.

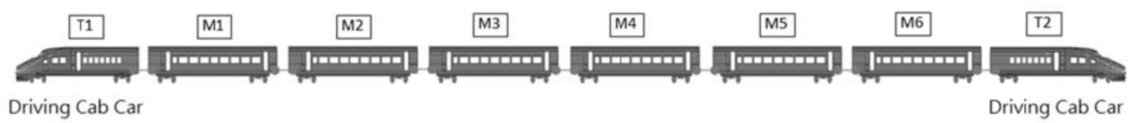


Figure 2: Car Configuration of XRL Train

According to the EN15227 standard, a simulation model of the train was built to correctly represent the weight of the carbody containing passengers which has to be maintained during the collision. Figure 3 was the FEA simulation model of the XRL train driving cab unit modelled with details using the well proven and popular LS-DYNA software. Crumple zone was the very front part of the cab which absorbs energy during a train collision. It was indicated in Figure 3 by circle.

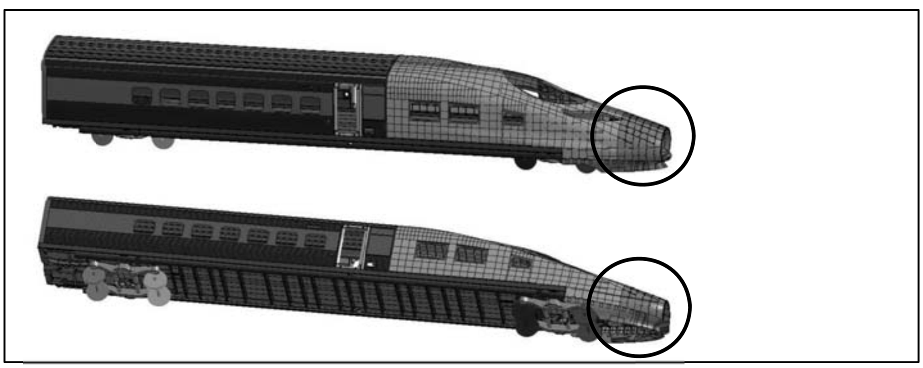


Figure 3: FEA Simulation Model of Cab Car Carbody

Materials Property Data

An important input data to the LS-DYNA simulation model would be the materials property data of the carbody structure in order to project the behaviour of displacement of the components due to external force and energy absorption during collision. Carbody of the XRL train is built with aluminium metal alloy materials and the behaviour property of the materials before and after they had collapsed due to the dynamic forces of collision would be needed for the FEA model.

A series of material tests were carried out to determine the deformation and damage behaviour of the aluminium metal alloy and their welded counterpart at different material zones under various failure scenarios during collision. Figure 4 below showed a set of samples prepared to do the tests for the aluminium metal alloy.

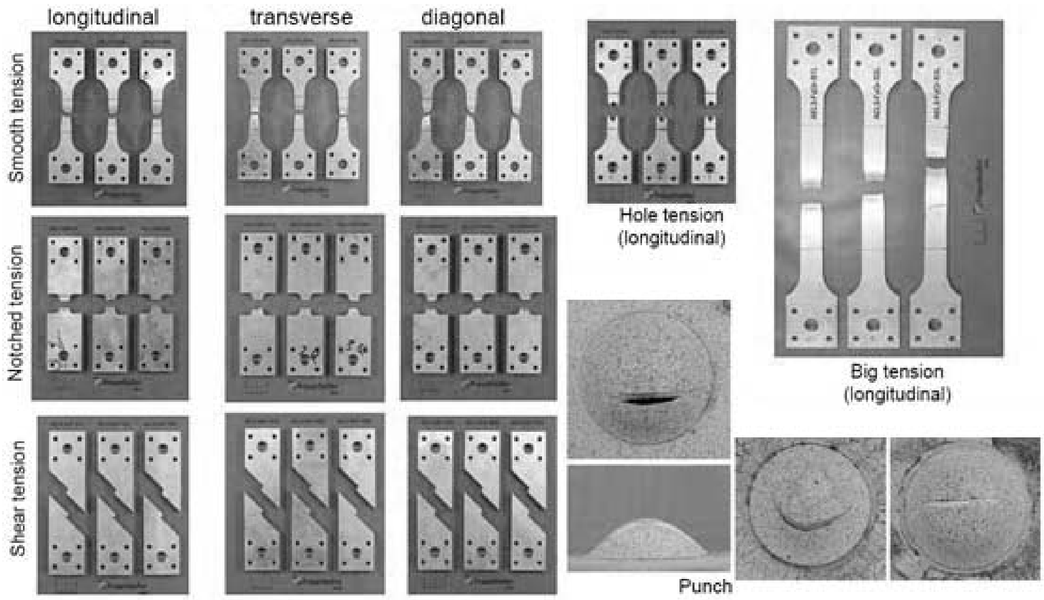


Figure 4: Samples of Test Specimens for Aluminium Metal Alloy

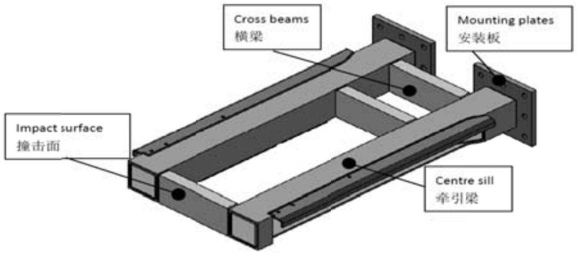
The results from these material tests were then input into the FEA model (ref. Figure 2) for the prediction of the energy absorption and deformation effect during train collision.

Computer Simulation Model Validation

Tests were carried out to calibrate the FEA model such that the FEA model and the result of the tests, through iterative process until both show consistent results. The FEA model is then considered accurate. As it would not be practical to crash a full size train in order to validate the accuracy of the simulation model, calibration tests were carried out on centre-sill cross beam component (Figure 5) of the XRL train end assembly involved in energy absorption during train collision. A FEA model for the centre-sill was developed using the same modelling technique that was adopted to build the full 8-car train FEA model (Figure 2). Estimated energy absorption for the centre-sill was then calculated based on the collision effect on these assemblies.

Figure 6 showed the test setup by crashing the test component onto a fixed rigid wall fitted with load cells to measure the collision force and high speed cameras to measure the impact speed of the wagon. Figure 7 presented the centre-sill assemblies before and after collision.

Figure 5: Centre sill-cross beam



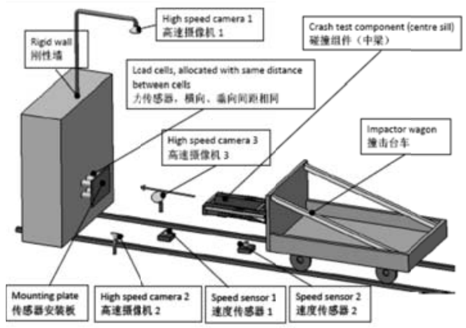


Figure 6: Test Setup

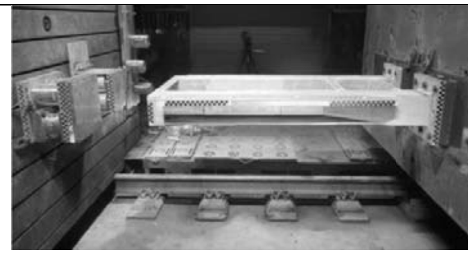
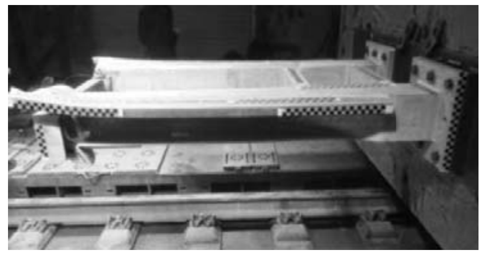


Figure 7: Shape of Centre-sill before and after Collision



By satisfying these four validation criteria set out by EN 15227 standard, it was confirmed that the modelling technique adopted for the FEA model was acceptable as it correctly represents the collision condition and effect when compared to the calibration tests:

(a) The same sequence of events occurs during the collision;

(b) The same observed deformation patterns occur;

(c) The level of energy dissipated by the model, mean force determined from the force-displacement graph and overall displacement (stroke) of the simulation was within 10% of the test value; and

(d) The simulation produces a global force curve which exhibits the same general characteristics as measured in the test.

Collision Analysis

Upon confirmation of the computer simulation modelling technique, assessment was carried out on the full 8-car train FEA model to analyse the result of the collision based on the stated scenario. Figure 8 showed the setup of the train on the track for the collision analysis. The deformation of the trains at the end of collision was presented in Figure 9.

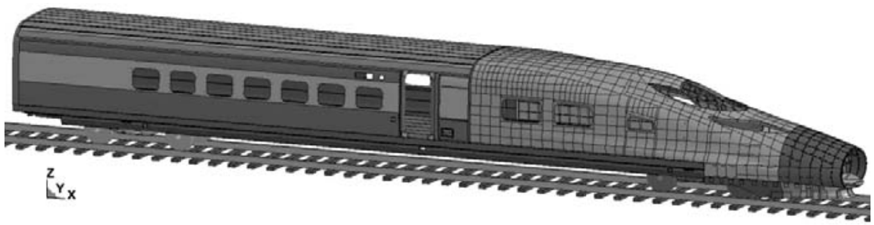


Figure 8: Train Setup on Track

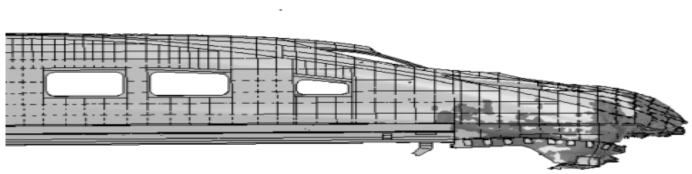


Figure 9: Deformation at Cab after Collision

During the course of the collision analysis, it was found that the crash behaviour of the train can be made better by changing coupler mounting arrangement of the cab front. This would be implemented for the nine CRH380A trains procured for the Hong Kong section of the XRL.

Conclusion

Based on the following results of the FEA Simulation, it is concluded that the simulation showed that the design and build of the train, CRH380A model procured for the Hong Kong section of the XRL, meet all the following criteria at a collision speed of 25km/h:

Item	**EN 15227 Criteria**	**Results**	
Overriding	Wheel lift-off distance up to 100mm.	Maximum lift-off distance of 54mm below the 100mm wheel lift-off distance.	**<u>ACHIEVED</u>**
Survival Space	Passenger area: Reduction in length to be no more than 50mm over any 5m length.	Passenger area length reduction is 7mm and it was lower than required 50mm over any 5m.	**<u>ACHIEVED</u>**
	Driving cab area: Clearance in front of the driver seat to be no less than 300mm.	Driving cab area length reduction is 11mm. The clearance in front of the driver's seat was more than required 300mm.	**<u>ACHIEVED</u>**
Deceleration Limit	Less than 5g (g = acceleration due to gravity)	Passenger space 1.9g; and Driver seat 2.0g	**<u>ACHIEVED</u>**