RA2021-1-II

RAILWAY ACCIDENT
INVESTIGATION REPORT

**Train derailment, accompanied to the level crossing accident,
in the premises of Kanagawa-shimmachi station,
Main Line, Keikyu Corporation**

February 18, 2021

JTSB Japan Transport Safety Board

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

TAKEDA Nobuo
Chairperson
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

《Reference》

The terms used to describe the results of the analysis in "3. ANALYSIS" of this report are as follows.

i) In case of being able to determine, the term "certain" or "certainly" is used.
ii) In case of being unable to determine but being almost certain, the term "highly probable" or "most likely" is used.
iii) In case of higher possibility, the term "probable" or "more likely" is used.
iv) In a case that there is a possibility, the term "likely" or "possible" is used.

Railway Accident Investigation Report

Railway operator	Keikyu Corporation
Accident type	Train derailment, accompanied to the level crossing accident
Date and time	About 11:43, September 5, 2019
Location	Kanagawa-shimmachi No.1 level crossing, the class 1 level crossing, in the premises of Kanagawa-shimmachi station, double track, Main Line, City of Yokohama, Kanagawa Prefecture

January 25, 2021

Adopted by the Japan Transport Safety Board

Chairperson	TAKEDA Nobuo
Member	OKUMURA Fuminao
Member	ISHIDA Hiroaki
Member	KAKISHIMA Yoshiko
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SYNOPSIS

<SUMMARY>

On Thursday, September 5, 2019, the outbound Limited Express KAITOKU 1088SH train, composed of eight vehicles and started from Aoto station bound for Misakiguchi station of Keikyu Corporation, departed from Keikyu Kawasaki station on schedule. While the train was running between Koyasu station and Kanagawa-shimmachi station at the velocity of about 120 km/h, the driver of the train noticed that the obstruction warning signal of Kanagawa-shimmachi No.1 level crossing was indicating the stop signal, then applied the service brake. After that, the driver noticed that the emergency inform device of Kanagawa-shimmachi station is also operating, then applied the emergency brake. After that, the driver of the Train noticed a standard sized truck entering the route of the Train in the level crossing, then sounded the whistle and operated the emergency alarm of the train protection radio, but the Train collided with the truck and stopped after passed about 67 m from the level crossing.

About 500 passengers, the driver and the conductor boarded on the Train, among them, 75 passengers, including 15 seriously injured passengers, and the driver and the conductor were

injured. In addition, the driver who was in the truck alone was dead.

Due to this collision, the 1st vehicle to the 3rd vehicle of the Train derailed and a part of the vehicle bodies and the apparatus were damaged. In addition, the truck had wrecked and caught fire.

<PROBABLE CAUSES>

The Japan Transport Safety Board concludes that probable cause of this accident was certain that the standard sized truck entered the Kanagawa-shimmachi No.1 level crossing and hindered the route of the train, and the train could not stop before the level crossing although the obstruction warning signal of the level crossing had been indicating the stop signal, then collided with the truck.

It is certain that the truck hindered the route of the train because the road warning device started the warning operation after the truck started to enter the level crossing, and completed the blocking operation before the truck had passed through the level crossing, then the truck stayed in the level crossing.

It is likely that the truck stayed in the level crossing because it took long time for the truck to pass through the level crossing due to the narrow width of the road against the size of the truck, when the truck turned right in the intersection and enter the level crossing.

As a side note, it is likely that the truck driver selected the route to the level crossing via the Urashima route 152 to bypass the usual route, related to that the truck could not operate in the usual route. However, it could not be determined why the truck passed the unusual route because the truck driver was dead.

The train could not stop before the level crossing, even though the obstruction warning signal of the level crossing had been indicating the stop signal. It is probable that this situation was caused because the driver of the train could not implement the braking operation to stop the train before the level crossing at the position where the indication of the obstruction warning signal of the level crossing became to be sighted from the driver of the train.

Concerning that the driver of the train could not implement the braking operation at the place where the driver became able to sight the operation of the obstruction warning device of the level crossing, it is probable that it was difficult for the driver to respond instantaneously to the obstruction warning signal that indicate the stop signal in unanticipated timing and therefore has the peculiarity. In addition, it is probable that the driver noticed with delay concerned with that there was the scene that the flickering status of the remote obstruction warning device was blocked intermittently by the masts, etc. in spite of the place where the obstruction warning device became to be sighted. As a side note, it is likely that the velocity when the train collided could be reduced if the Driver had operated the emergency stop procedures by the emergency brake when operated the service brake. However, the company stipulated to use the service brake to stop the train as the principle under the rule "when the stop signal was indicated in the obstruction warning device, stop immediately". And the company had entrusted the driver with the judgement to operate the service brake or the emergency brake, considering the status as the velocity, distance, etc.

Therefore, it is likely that the above situation was caused related with that the brake to be used had not been prescribed clearly in the implementing standard of handling operation and the working standard of the driver of electric railcar.

CONTENTS

ATTACHED MATERIALS

1. PROCESS AND PROGRESS OF THE RAILWAY ACCIDENT INVESTIGATION

1.1. Summary of the Railway Accident

On Thursday, September 5, 2019, the outbound Limited Express KAITOKU 1088SH train, composed of eight vehicles started from Aoto station bound for Misakiguchi station of Keikyu Corporation, departed from Keikyu Kawasaki station on schedule. While the train was running between Koyasu station and Kanagawa-shimmachi station at the velocity of about 120 km/h, the driver of the train noticed that the obstruction warning signal of Kanagawa-shimmachi No.1 level crossing was indicating the stop signal, then applied the service brake. After that, the driver noticed that the emergency information device of Kanagawa-shimmachi station is also operating, then applied the emergency brake. After that, the driver of the train noticed a standard sized truck entering the route of the train in the level crossing, then sounded the whistle and operated the emergency alarm of the train protection radio, but the train collided with the truck and stopped after passed about 67 m from the level crossing.

About 500 passengers, the driver and the conductor were boarded on the train, among them, 75 passengers, including 15 seriously injured passengers, and the driver and the conductor were injured. In addition, the driver who was in the truck alone was dead.

Due to this collision, the 1st vehicle to the 3rd vehicle of the train derailed and a part of the vehicle bodies and the apparatus were damaged. *Here, the words "front", "rear", "left" and "right" are defined based on the running direction of the train as far as commented particularly, and the vehicles were counted from the front*. In addition, the truck had wrecked and caught fire.

1.2. Summary of the Railway Accident Investigation

1.2.1. Organization of the Investigation

On September 9, 2019, the Japan Transport Safety Board, *hereinafter referred to as "the JTSB"*, designated an investigator-in-charge and the other three railway accident investigators to investigate this accident. In addition, the JTSB dispatched the board members to the accident site, etc.

The Kanto District Transport Bureau dispatched its staffs to the accident site to support the investigation of this accident.

In addition, the Accident Investigation Committee of Business Use Automobile, established by the Road Transport Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, treated this accident as the accident by the business use automobile and implemented the investigation and analysis on the accident of the business use automobile and the causes of the damages accompanied with the accident,.

1.2.2. Implementation of the Investigation

September 5 to 7, 2019	On-site investigation, vehicle investigation, hearing statements
September 13, 2019	Vehicle investigation
September 20, 2019	Investigation of the standard sized truck

October 4, 2019	Vehicle investigation and hearing statements
October 31, 2019	On-site investigation
November 21, 2019	On-site investigation
December 10, 2019	Vehicle investigation
February 6, 2020	Hearing statements, On-site investigation
February 28, 2020	Vehicle investigation
March 11, 2020	Vehicle investigation
April 9, 2020	Vehicle investigation
July 7, 2020	Investigation of the standard sized truck

1.2.3. Comments from Parties Relevant

Comments were invited from parties relevant to the cause of the accident.

2. FACTUAL INFORMATION

2.1. Process of the Train Operation

2.1.1. Statements of the Train Crews, etc. *[Refer to Attached Figures 1 to 6]*

The summary of the process to the accident was as follows, based on the statements of the driver and the conductor of the outbound Limited Express KAITOKU 1088SH train, composed of eight vehicles and started from Aoto station of Keisei Main Line bound for Misakiguchi station of Keikyu Corporation, *hereinafter referred to as "the Driver", "the Conductor", "the Train", "the Company", respectively*, and the driver of the outbound local 1056 train which had been waiting the passing of the Train at Kanagawa-shimmachi station before the occurrence of the accident, two staffs of the Company presented at the accident site, the representative of the trucking company that the driver of the standard sized truck[*1] had been working, and two passengers boarded on the Train, *hereinafter referred to as "the Driver of the 1056 train", "the 1056 train", "the company Staff A", "the company Staff B", "the Truck driver", "the Truck", "the Passenger A", "the Passenger B", respectively*.

(1) The Driver

I was on duty as the driver of the Train from Sengakuji station. On the occurrence day of this accident, my physical condition was good and there was no abnormal status in my physical condition. In addition, I did not feel any abnormal status in the vehicles of the Train from when started my duty of the Train to the occurrence of this accident.

The Train departed from Keikyu Kawasaki station, at 11,775 m from Shinagawa station, *hereinafter "from Shinagawa station" is omitted*, on schedule at 11:38, toward the next stop, *i.e.*, Yokohama station. After departed, while the Train was running in around Koyasu station, that is the non-stop station at 19,300 m, at the velocity of about 120 km/h, I tried to check the No.1 home signal of Kanagawa-shimmachi station, at 19,946 m, at around the place where the front head of the Train passed through Koyasu station, and noticed the indication of the stop signal in

the obstruction warning signal[*2], *hereinafter referred to as "the OWS" refer to 2.4.2.4 (3),* of Kanagawa-shimmachi No.1 level crossing, at 19,970 m, *hereinafter referred to as "the Level crossing"*, installed in the most distant place in the direction to Koyasu station from the Level crossing, among the OWSs located in the direction to Kanagawa-shimmach station from the No.1 home signal of Kanagawa-shimmachi station. Therefore, I operated the service brake. *Here, three OWSs of the Level crossing were planted against the outbound trains and named as "the close OWS", "the middle OWS", and "the distant OWS", respectively, in turns from the nearest one to the Level crossing*. At this moment, I could not confirm visually the status of the Truck hindering the Level crossing, and did not notice any hindrance on the route of the Train.

After that, I noticed that the middle OWS installed on the platform of Kanagawa-shimmachi station and the alarm reporting device[*3] of the station were operating. As I judged that the Train cannot stopped before the Level crossing by the service brake, I operated the emergency brake.

I noticed the Truck, which was entering the route of the Train from right side of the Level crossing, in around the place where the Train approached the Koyasu station side edge of the platform of down track of Kanagawa-shimmachi station. Therefore, I sounded a whistle immediately and operated the switch to issue emergency alarm of the train protection radio[*4]. After that I thought that the collision with the Truck is inevitable, and operated the emergency switch[*5]. But it was too late, the Train collided with the loading platform of the Truck. After collided, the front glass of the Train was cracked like cobweb and became to the status in which I could not see forward, and the vehicle body of the 1st vehicle was tilted to right and stopped accompanied by the sound as crashed and scraped.

When the Train stopped, I was thrown from the driver's seat and was carried away to right side in the driver's cab, and was sitting to lean against around the door for getting on and off. Then, I stood up and tried to communicate with the Conductor that the train collided with the truck, using the corresponding microphone, but there was no response from the Conductor at that time.

After tried to communicate with the Conductor, I looked inside the cabin and confirmed the status such that the passengers fell down, and found that the black smoke and the flame rising from left side of the 1st vehicle. At that time, a few passengers already tried to escape to outside through right window of the 1st vehicle, then I looked the up track, where the facing trains are operating, whether there was the approaching train or not, and found that the facing train stopped in Nakakido station, *the present name is Keikyu Higashi Kanagawa station*. Then, I entered the cabin from the rear door of the driver's cab, and handle the door cock to open two doors in right side of the 1st vehicle in turns from the front, and guided the passengers in the 1st vehicle to get off train to the track. As a passenger remained in the 1st vehicle was using the stick, I got off the train in advance and assisted the passenger to detrain, and thus I guided all passengers in the 1st train outside vehicle.

As many company staffs, etc., rushed to the accident site from Kanagawa-shimmachi station and the Shimmachi Crew Office in the same station, and guided the passengers to evacuate to the direction of Kanagawa-shimmachi station, then I guided the passengers for evacuation in

cooperation with them. When I guided passengers, I checked the 2nd vehicle and confirmed that the detrainment of the passengers was completed.

Because a fire broke out from the lower part of the vehicle body of the 1st vehicle, I tried to go to put out a fire by the fire distinguisher together with a few company staffs, but the large flame broke out from around the Truck, then judged as the fire fighting by the fire distinguisher was impossible, and evacuated to the direction of Kanagawa-shimmachi station.

After evacuated, I was treated the first aid for the injured parts in the Shimmachi Crew Office and was transferred to the hospital. I remembered that the time from the occurrence of the accident to the time when I had transferred was a little shorter than one hour.

*1 *"Standard sized truck" in this context is the category prescribed in the Article 2, Category of automobiles, of the Road Transport Vehicle Law, Law No. 185, 1951. Here, the standard sized automobile is the automobile, except for the compact automobile, the light automobile, the large special-purpose vehicle and the compact special-purpose vehicle, and larger than the compact automobile with 4 wheels or above. Furthermore, the Truck was categorized as the large-sized vehicle, in the Article 3, Category of automobiles, of the Road Traffic Law, No. 105, Law, 1960.*

*2 *"Obstruction warning signal" in this context is the signal to indicate the stop signal when detected the abnormal status by linked together with the detected results of the obstruction warning device for level crossing, obstruction detecting device for level crossing, etc. Here, the Company prescribed as "flashing light signal" but described in the report as "obstruction warning signal".*

*3 *"Alarm reporting device" is installed in the stations, etc., of the Company for the purpose to let the driver or the conductor operate emergency stop by operated the device when a passenger fell to the track, as the safety measure against the fallen accident from platform. According to the working standard of the driver of electric railcar, the company regulation, of the Company, to operate the stop procedures immediately when confirmed the alternate lightening of upper and lower or left and right red lamps, or the sounding warning buzzer.*

*4 *"Train protection radio" is the radio used to arrange the emergency stop procedures for the train protection. The radio wave was transmitted to the trains existed within 1 to 1.5 km, and the trains received the radio wave operated the emergency stop immediately.*

*5 *"Emergency switch" in this context is the switch, equipped in the vehicles of the Company, which can operate the emergency brake, the issuance of the train protection radio, the lowering pantograph, simultaneously.*

(2) The Conductor

The Train departed from Keikyu Kawasaki station on schedule at 11:38. The issuance signal of the train protection radio sounded when the Train passed Koyasu station. I thought that the train would stop suddenly and tried to take the microphone of the public address system to announce that the train would stop suddenly to the passengers, at that instant, there was the shock. After the train stopped, I announced to the passengers "the train stopped for the emergency, please wait until to confirm the situation". After that, I called the Driver using the communication microphone in order to confirm the situation, but there was no response, then announced to the passengers that "please wait for a while as I would check the site". The Train stopped when the rear vehicles faced to the platform of the down track of Kanagawa-shimmachi station, therefore I got off the train to the platform from the left door for the train crews, and found the smoke and flame from the front of the Train. When I tried to go back inside vehicle of the Train in order to implement guidance for evacuation of the passengers, many company staffs who noticed the occurrence of the accident rushed to the

Train and they had implemented the guidance for evacuation by manually opening the doors for getting on and off. Then I went back inside vehicle and repeated the announcement to the passengers that "passengers were requested to evacuate, please obey the instructions of the staffs". After completed the evacuation of the passengers, I checked that there was no passenger in the cabins and on the platform, after that I left from the site.

Additionally, I was injured by the shock at the accident, and was transferred to the hospital.

(3) The company staffs who witnessed this accident in around the site

(i) The Driver of the 1056 train

I was waiting for arrival of the train assigned as my duty, in the platform of down line of Kanagawa-shimmachi station at about 11:35, in order to start my duty for the 1056 train bound for Uraga station and scheduled to depart from Kanagawa-shimmachi station at 11:44. The 1056 train arrived at No.1 track on schedule at 11:37, and I was handed over from the predecessor. After that, when I moved to the side of No.2 track, where the Train is scheduled to pass through, in order to watch the passing of the Train on the platform, the road warning device of the Level crossing started the warning operation and sounded the warning sound, *i.e.*, the sound of buzzer, showing the operation of the obstruction warning device for level crossing[*6], *hereinafter referred to as "the OWD"*, of the Level crossing. When the warning sound sounded, the close OWS had been operating.

When I moved to the edge of the platform in the direction to Nakakido station, in order to check the status of the Level crossing, the Truck had been hindered the up line, and the Truck was moving forward although the Truck seemed to move backward. Therefore, I pushed the emergency alarm button of the abnormality alarm device installed on the platform of the station. I remembered that it was about 10 seconds after the crossing gate of the Level crossing completed the closing operation. Because I felt that the approaching train could not stop before the Level crossing, I evacuated to the side of No.1 track on the platform.

Additionally, the Train was sounding the whistle before the collision, but I did not remember when the sounding had started. After the collision, I went to the driver's cab of the 1056 train in order to operate the train protection radio to implement the train protection procedures, but the warning sound that showed receiving of the alarm signal was sounding. Therefore, I implemented the guidance for evacuation of the passengers of the Train, obeying to the instruction by the company staffs rushed from Kanagawa-shimmachi station to the site.

*6 *"Obstruction warning device for level crossing" is the facility to indicate the stop signal to the trains by the flashing signal, etc., by the operation device, i.e., the push button, or the obstruction detecting device for level crossing when the hindrance such as that the automobile could not move in the level crossing, etc.*

(ii) The company Staff A

At about 11:30, when I went out of the station from the west ticket barrier of Kanagawa-shimmachi station together with the company Staff B, I noticed the Truck moving to the Level crossing from the direction of Nakakido station in the road neighboring to the railway track. When we were going to cross the level crossing, the Truck driver talked to us that he would like to turn left, to the opposite side of the Level crossing, and asked us to

watch the rear part of the Truck. Then I, together with the company Staff B, was watching the status of the Truck, which was trying to turn left repeatingforward and backward movement, around the operating device, *i.e.*, the push button, of the OWD installed in right side, in the direction to Nakakido station, of the Level crossing. However, the Truck driver told us to turn right because the left turn seemed to be difficult. The Truck entered the Level crossing in order to turn right, but could not turn right entirely, then the Truck moved backward outside of the Level crossing once. When the Truck entered the Level crossing again to try to turn right again, I heard the sound like something snapped from around the rear load-carrying platform, *i.e.*, rear left part, of the Truck. Therefore, I went to the rear side of the Truck and found that the Truck had contacted with the traffic sign. After that, the road warning device started the warning operation, but the Truck had been moving forward and backward repeatedly as the situation was difficult to move backward because the rear part of the Truck contacted with the traffic sign. Then, the crossing rod of the crossing gate started lowering, therefore, I lifted up the crossing rod by hands together with the company Staff B, so that the Truck could evacuate to outside of the level crossing. At this time, the company Staff B pushed the push button of the OWD. The Truck driver tried to turn right repeating the movement in forward and backward. When the Truck turned right completely and faced in the direction same as the road in the Level crossing, it was in the status where the Truck hindered the up line and the down line. At this time, I found the Train approaching from the side of Koyasu station. I judged as dangerous and went back 2 to 3 m from there together with the company Staff B, at that time, I witnessed the status of the collision of the Train and the Truck. After the collision, I saw the smoke rose from around the 1st vehicle of the Train, I judged something burning, and rushed to Shimmachi Crew Office located next to the station and asked to call the fire engines. When I went back to the Level crossing, the company staffs, who noticed the accident rushed to the accident site, entered the track and went toward the front direction of the Train, then, I went together with them. Because the passengers were trying to evacuate from windows in the 1st vehicle, I assisted to detrain. After that, I implemented the guidance for evacuation of the passengers in cooperation with the company staffs in the site.

(iii) The company Staff B

I saw the Truck when I went out from west exit barrier of Kanagawa-shimmachi station together with the company Staff A, at about 11:30. When we went to cross the level crossing, the Truck driver talked and asked us to watch the rear of the Truck because he would like to turn left. I was watching the status of the Truck trying to turn left, together with the company Staff A. After that, when the Truck tried to turn right, the road warning device started the warning operation. As the front of the Truck was hindering the railway tracks in the Level crossing, I pushed the push button of the OWD. After that, the crossing rod of the crossing gate started lowering. Because I thought that the Truck driver would move the Truck backward outside of the Level crossing, I suspended the crossing rod of the crossing gate by hands together with the company Staff A so that the Truck canevacuate easily. However, the Truck moved forward and stopped temporary in the position hindering the down line in the

Level crossing. Because the Train approached the Level crossing when the Truck moved forward again, I thought that the Train would collide with the Truck. Therefore I went back 2 to 3 m from there not to be involved in the collision, at that moment, I saw the status of the collision of the Train and the Truck. After the collision, I rushed to the Shimmachi Crew Office and informed the occurrence of the accident to the company staffs. After that, I went back to the site and implemented the guidance for evacuation of the passengers in cooperation with the company staffs in the site.

(4) The representative of the trucking company

The Truck driver went to the office at about 04:00 in the morning of the day of this accident, and departed toward the loading site in the City of Yokohama at about 04:10, after confirmed that there was no abnormal situation in the Truck by implementing the vehicle inspection before started his duty. The roll call on the day of this accident had not been implemented, because the staff engaged to enforce roll call was absent, but the Truck driver had implemented the alcohol check by himself, and I remembered that there was no problem in the result of the alcohol check.

The Truck arrived at the loading site at about 07:40, and departed there at about 11:20 after loaded the freights. The Truck had scheduled to transport the freights to the unloading site in Narita City. I do not know the reason that the Truck driver passed the Level crossing, because he had the experience charged in the works to transport the freights between the similar loading and unloading sites and the Level crossing was not in the route operated as usual.

In addition, although it is the information known after this accident, it might be in the status in which it is necessary to bypass because the entrance of the metropolitan express way where used usually in the return route was closed on the day of this accident. According to the Metropolitan Expressway Company Limited, the repairing works to install the machine to weigh the axle load in the toll gate of Koyasu entry of the up lane of Yokohane route of the Express Kanagawa No.1 route had been implemented from September 1 to November 20, including the day of the occurrence of this accident. Then the entrance was closed on the day of this accident.

The concerned Truck driver had been employed by the Truck driving company from October 2018, I heard that the Truck driver had the experience to drive the truck before that time. After employed, there was no accident or violation, etc., and the work attitude was good. He had the driver's license for large-sized vehicle, and possessed the requirement to drive the Truck. I think that the Truck driver wore the glasses at the time of this accident, because the driver usually wore the glasses although his driver's license prescribed "glass, etc." as conditions. As for the physical condition of the Truck driver, there was no abnormal status in the results of the health examination implemented by the company, and there was no problem in the sense of sight and the sense of hearing. I think that there was no physical problem to affect the driving operation.

The concerned trucking company purchased the Truck in 2002, the indicated value of the odometer at the time of the vehicle inspection implemented on December 2018 was 203,100

km, and there was no trouble, etc., to affect the hindrance for the running.

(5) The passengers of the Train

(i) The Passenger A

I was seated in the rear door side of the long seat, between the middle and the rear doors in left side of the 1st vehicle. It was not so crowded and there was no standing passenger.

I had been sleeping just before the accident, but woke up by the sound of the whistle and, at the same time, the passengers boarded in forward were moving backward. Then, I looked forward and found something like block on the railway track, just after that the Train collided. After collided, the vehicle was tilting with shaking wobbly. Suddenly, I hold the hand rail by right hand, and tried to hold by left hand too, but I was thrown away and fell down on the floor. After that, I saw the fire broke out outside the vehicle. I heard the voice from the surrounding to escape in a hurry. As there were some passengers getting off the train from the coupled part between the 1st and the 2nd vehicles, the persons already got off the train told to get off from the windows, then, I got off the train from right side window.

After the accident, I was transferred to the hospital. I was diagnosed as the broken bone of left elbow and the cervical sprain.

(ii) The Passenger B

I was standing by holding the hanging strap around the seat between the front and the middle doors in left side of the 3rd vehicle. The all around seats were filled up but a few persons were standing. I did not notice the whistle and the deceleration just before the accident, resulted from the shock of the collision, my hand removed from the hanging strap and I was thrown off for about 2 m and fell down on the floor. After collided, I moved to the rear vehicle by the guidance of the rushed company staffs, and went out to the platform of Kanagawa-shimmachi station.

After the accident, I was transferred to the hospital, and diagnosed as the broken bone of left wrist and the broken and damaged root of the teeth.

2.1.2. Records of the Operating Status

The event recorder was equipped in the Train, and recorded the information on the time, the velocity, the running distance, the braking command, etc.

The major records in the time span between the departure from Keikyu Kawasaki station and the occurrence of this accident, recorded in the event recorder were as shown in Table 1.

Table 1. Operating status in before and after the occurrence of this accident, extracted only the major records

Time	Velocity [km/h]	Running distance [m]	Brake command	Remarks Estimated status of the Train
11:38:46	0	0		Departed from Keikyu Kawasaki station
11:42:39	117	6,879	-	Powering[*7] operated, OWS operated
11:43:01	118	7,596	-	Running where the remote OWS is visible

11:43:03	120	7,675	-	Notch off
11:43:05	119	7,742	Bl	Service brake operated
11:43:06	118	7,774	B2	Service brake operated
11:43:07	117	7,794	B3	Service brake operated
11:43:07	116	7,807	B4	Service brake operated
11:43:07	115	7,813	B5	Maximum service brake operated
11:43:11	101	7,920	Emergency	Emergency brake operated
11:43:22	62	8,166	↑	Velocity suddenly decreased considered as caused by the collision

* "Time" data were revised based in the actual time.

* "Running distance" indicated the accumulated running distance from the departure from Keikyu Kawasaki station.

* Characters and numbers in "brake command" indicated that the brake command based on the lever position, *i.e.*, number of steps, of the brake handle.

* "Velocity" and "running distance" data have the possibility to include errors.

* The correct records of after collision were not remained because the device had destroyed.

*7 *"Powering" is to operate the train in the accelerating operation.*

2.2. Human Death, Missing, and Injuries

2.2.1. Information on the Injured Persons, etc.

The Truck driver was dead by this accident. In addition, according to the Company, about 500 passengers and 2 train crews, *i.e.*, the Driver and the Conductor, were boarded on the Train, and 75 passengers were injured. The levels of the injuries were as follows.

The Truck driver Dead

The passengers 15 were seriously injured, 60 were slightly injured

The Driver Slightly injured

The Conductor Slightly injured

The injured statuses of the passengers in each vehicle were as shown in Table 2 and Table 3.

Table 2. Injured level of passengers in each vehicle as of October, 2020 [persons]

	1st vehicle	2nd vehicle	3rd vehicle	4th vehicle	5th vehicle	6th vehicle	7th vehicle	8th vehicle	Unknown	Total
Seriously injured	6	2	2	3	—	—	—	2	—	15
Slightly injured	28	4	6	8	4	3	3	3	1	60
Total	34	6	8	11	4	3	3	5	1	75

* The "seriously injured" is the injuries required the treatment by the doctors for over 30 days, and the "slightly injured" is the injuries other than the seriously injured persons, based on the Notification Prescribed the Format of the Report, etc., on Railway Operation Accident, Notification No.1387 of the Ministry of Land, Infrastructure, Transport and Tourism, 2001.

Table 3. Injured level of passengers in each vehicle as of October, 2020 [persons]

	1st vehicle	2nd vehicle	3rd vehicle	4th vehicle	5th vehicle	6th vehicle	7th vehicle	8th vehicle	Unknown	Total
Wound, contusion, etc.	12	1	2	4	2	—	1	2	—	24
Blow, wrench, etc.	22	4	5	9	3	—	3	4	—	50
Whiplash, etc.	4	1	1	1	1	2	—	2	—	12
Others	12	4	1	1	1	1	—	3	1	24
Total	50	10	9	15	7	3	4	11	1	110

* "Total" in the above table included the passengers of plural injuries, therefore, different from the total injured persons.

2.3. Information on the Truck

2.3.1. Outline and the Damaged Status of the Truck *[Refer to Attached Figure 8]*

According to the information described in the vehicle inspection certificate of the Truck, the outline of the Truck was as follows.

Shape of vehicle body	Van
Length × width × height	11.99 m × 2.49 m × 3.79 m
Vehicle weight	11,640 kg
Maximum payload	13,200 kg
Kind of fuel	Light oil
Initial registration	September 2002

The status of the major damages by this accident of the Truck were the damages and deformations around the center part of left side of the load-carrying platform considered as caused by collision with the Train. In addition, there were the damages and deformations, considered that the bogie of the 1st vehicle of the Train climbed up after collided, from the assistant driver's seat to the driver's seat, and the cabin was damaged by a fire. Additionally, there was the trace considered as caused by hit with the mast planted in the direction of Nakakido station of the Level crossing, around the rear wheels in right side of the load-carrying platform.

2.3.2. Information on the Inspection, etc., of the Truck

According to the representative of the trucking company, there was no record showing abnormal situation to affect the hindrance of the running operation of the Truck, in the latest periodic inspection and maintenance, etc., of the Truck.

2.4. Information on the Railway Facilities, etc.

2.4.1. Information on the Periphery of the Accident Site

2.4.1.1. Status of the periphery of the Level crossing

Kanagawa-shimmachi station, and the Shimmachi Crew Office next to the concerned station are located in around the Level crossing, and there were the commercial facilities and the

houses, etc., in addition to the railway facilities of the Company around the concerned station.

The National Highway route 15 and the Metropolitan Expressway run parallel in south of the main line of the Company. Furthermore, Tokaido Line of the East Japan Railway Company run parallel in the north of the Level crossing, on either side of the Shimmachi Vehicle Inspection Depot of the Company and the Urashima park.

2.4.1.2. Status of the road connected to the Level crossing

The road crossing the Level crossing was the city road Urashima route 44, *hereinafter referred to as "the Urashima route 44"*, which is managed by the City of Yokohama. Furthermore, the city road Urashima route 152, *hereinafter referred to as "the Urashima route 152"*, merged the Urashima route 44 around right side entrance of the Level crossing, run parallel to the railway tracks. The status of the periphery of the Level crossing was shown in Figure 1.

The width of the Urashima route 152 was about 3.7 m around the place connected with the Urashima route 44. Additionally, there were the traffic sign and the auxiliary sign indicating the limit speed and end of the speed control section, and the traffic sign to prohibit proceeding in the direction not designated, planted in both sides of the road. The span of these signs was about 3.3 m. Width of the Urashima route 44 was about 11.1 m around the place connected to the Urashima 152, same as the width described later in the paragraph 2.4.2.3.

In addition, the traffic sign indicating the start of the maximum speed 30 km/h, and the traffic sign indicating no parking, were planted around the ending point of the Urashima route 152.

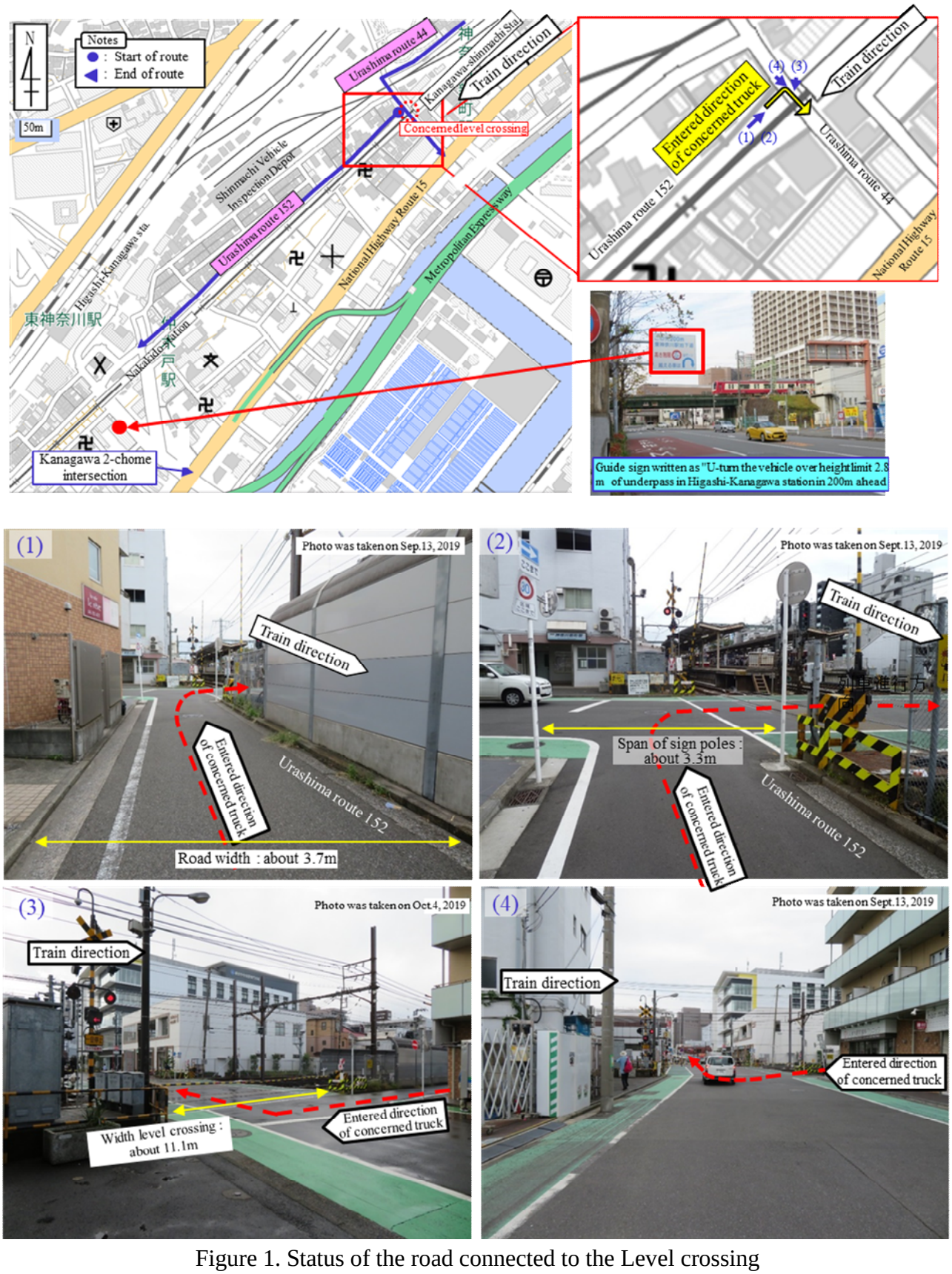


Figure 1. Status of the road connected to the Level crossing

*This figure was made using the Geographical Institute Map, Electrical Country Web, of the Geospatial Information Authority of Japan, based on the information of "the system providing the map information on the administrative ward of the City of Yokohama", the approved route map, of the City of Yokohama.

Furthermore, the guidance sign, written as "U-turn the vehicle which exceeds height limit

2.8 m of the underpass of Higashi Kanagawa station in 200 m ahead", had been planted in left side of the road toward Nakakido station from Kanagawa 2-chome intersection. The traffic sign indicating the start of one-way road was planted in the place about 100 m toward the ending point from the starting point of the Urashima route 152, *i.e.*, the Urashima route 152 was the one-way road from the ending point toward the starting point.

2.4.2. Information on the Railway Facilities

2.4.2.1. Outline of the route *[Refer to Attached Figure 1]*

The Main Line of the Company was the railway business mile of 56.7 km from Sengakuji station to Uraga station, the double track, the electrified section by DC 1,500 V and the gauge of 1,435 mm.

In addition, the Main Line connected to the Kurihama Line, 13.4 km long section between Horinouchi station and Misakiguchi station, at Horinouchi station.

2.4.2.2. Outline of the railway track *[Refer to Attached Figures 2, 3]*

The information on the railway track and the railway facilities around the Level crossing, *i.e.*, this accident site, was as follows.

(1) The track shape of the Koyasu station side in around the Level crossing was the 800 m radius left curve including the intermediate transition curve[*8] and the transition curve from 19,046 m to 19,639 m, the straight track from 19,639 m to the Level crossing. The gradient was flat from 19,216 m to around 19,978 m across the Level crossing.

(2) Koyasu station is located in 19,300 m, *i.e.*, at about 670 m in the direction to Shinagawa station, and Kanagawa-shimmachi station is located in 19,946 m, *i.e.*, at about 24 m in the direction to Shinagawa station, from the Level crossing.

(3) As for the home signal for the outbound train entering Kanagawa-shimmachi station, the outbound No.1 home signal was planted in 19,554 m, and the outbound No.2 home signal was planted in 19,799 m.

(4) In Kanagawa-shimmachi station, four tracks were laid for two platforms. The No.1 track and the No.2 track were the down lines, the No.3 track and the No.4 track were the up lines.

(5) Koyasu No.1 level crossing was located in 19,459 m, *i*.e., 511 m in the direction to Shinagawa station from the Level crossing.

*8 *"Intermediate transition curve" is the transition curve inserted between two circular curves in the compound curve, i.e., the curve composed of the circular curves of the radiuses above two kinds.*

2.4.2.3. Outline of the Level crossing

(1) Based on the table on the investigated results of the actual condition of level crossings, FY 2014, submitted from the Company, the outline of the Level crossing was as follows.

(i) Name of level crossing	Kanagawa-shimmachi No.1 level crossing
(ii) Kilometerage	19,970 m
(iii) Category of level crossing	Class 1

(iv) Overall width of level crossing 11.1 m

(v) Length of level crossing 19.4 m

(vi) Intersection angle of track and road 90°

(vii) Gradient of the road 0/100 rightward from the Train

(viii) Sighting distance of level crossing[*9] 400 m from the Train

(ix) Sighting distance of the train[*10] 100 m from entered side of the Truck

(x) Traffic control Nothing

(xi) Road traffic volume

Automobile above 3 wheels	468 vehicles/day
Two-wheeled vehicle	72 vehicles/day
Light vehicle	545 vehicles/day
Pedestrian	1,811 persons/day

(xii) Railway traffic volume 697 trains/day

(xiii) History of accident Nothing, after November 2001

(xiv) Obstruction warning device for level crossing Equipped

(xv) Obstruction detecting device for level crossing[*11] Equipped, 3D laser radar type

*9 *"Sighting distance of level crossing" is the maximum distance that the level crossing on the Route can be sighted, from the driver's seat of the train.*

*10 *"Sighting distance of the train" is the position of the train, expressed by the distance from the center line of the level crossing and the train, where the train can be sighted from the place 5 m outside from the crossing point of the road and the level crossing, on the center line of the road, at the height of 1.2 m.*

*11 *"Obstruction detecting device for level crossing" is the device to detect the obstacles in the level crossing automatically and operate the obstruction warning device for level crossing automatically based on the detected information.*

(2) According to the Company, the accident had never occurred in the Level crossing in the past, at least after November 2001. In addition, the incidents that hindered the train operation because the stop signal was indicated in the OWS due to the hindrance of level crossing, etc., in the past 5 years before the occurrence of this accident were as shown in Table 4.

Table 4. Examples of the hindrance of train operation by the operation of the OWS in the Level crossing, as of September 2019.

Date & year	Time	Obstruction	Hindered time	Remarks
Nov. 21, 2014	09:34	Nothing	1 minute	The push button was operated
April 2, 2017	15:48	Entrance of the public	1 minute	Obstruction detecting device for level crossing was operated
Jan. 6, 2019	17:32	Nothing	2 minutes	Obstruction detecting device for level crossing malfunctioned due to the poor detecting sensor.

(3) The train direction indicator in the Level crossing

The train direction indicator, shown in Figure 2, was attached to the prop for the road warning device in the Level crossing, and the red arrow lamp to indicate the direction of the approaching train, turns on while the road warning device is in the warning operation.

Figure 2. Train direction indicator in the Level crossing

2.4.2.4. Outline of the OWD in the Level crossing

The OWD, which indicate the stop signal against the train by the detected result of the three-dimensional laser radar type obstruction detecting device for level crossing, or the operation of the operating device, *i.e.*, the push button, when it is necessary to protect trains against the hindrance occurred in the level crossing, was installed in the Level crossing. The outline of the functions, etc., of the OWD was as follows.

(1) Information on the obstruction detecting device for level crossing

The obstruction detecting device of the Level crossing was set to start detection of the obstacles from 4 seconds after the road warning device started the warning operation. The device recording the operating status was equipped to the obstruction detecting device, and recorded the information showing that the obstacle was detected about 4 seconds after the road warning device of the Level crossing started the warning operation, before the occurrence of the Level crossing.

In addition, the three-dimensional laser radar type obstruction detecting device for level crossing detected the obstacles by the emitted and irradiated laser light from two laser radar heads mounted on left and right of the upper part of the concrete column in the direction to Nakakido station of the Level crossing, refer to Figure 3. And the obstruction detecting device have the ability to detect the obstacles sized above 1 m × 1 m × 1 m, in the area within 30 m distant from the laser radar head.

Figure 3. Laser radar head of the obstruction detecting device for level crossing

(2) Information on the operating device

The push button type operating devices were installed in 4 places in left and right of front and rear of the Level crossing. When the push button is operated, the red lamp next to the push button is turned on, and then enables to be identified the place of the operated push button, and the red lamp holds the turned on status until the release operation is implemented, as the specification. The red lamp of the operating device located in front right viewed from the entering truck, *i.e.* in the direction to Nakakido station, of the Level crossing, had been turned onand showed it is operated, when the inspection was implemented on the day of the occurrence of this accident, as shown in Figure 4. Additionally, the function to record the operation of the operating device had not been prepared.

Figure 4. The operating device, *i.e.*, the push button, of the Level crossing

(3) Information on the obstruction warning signal, OWS

The OWS indicate the stop signal against the driver of the train by the flickering OWS planted in the track side when the OWD described in the above (1) detected the obstacle, or the push button of the operating device described in the above (2) was pushed. The display part of the OWS was composed of the circular black back plate of 480 mm diameter, and four circular red lamps of 120 mm diameter, laid out two lamps in vertical and two lamps in lateral. When the OWS is operating, all four lamps are flickering simultaneously in the frequency of 84 times per minute.

Three OWSs against the outbound train were installed for the Level crossing, and the remote OWS, the middle OWS, and the close OWS were installed in the positions at 19,574 m, 19,837 m, and 19,962 m, respectively. Additionally, the function to back up the driver, such as to cooperate with the safety system of the automatic train stop device, etc., was not added to the OWD in the Level crossing in order to stop or decelerate the train when the stop signal was indicated against the train due to the detection of obstacle by the obstruction detection device for level crossing or the operation of the operating device, *i.e.*, the push button.

According to the record on the changed facilities of signaling system of the Company, the OWSs for the Level crossing were installed on September 1981, and the planted positions were not changed after installed, according to the Company.

Figure 5. Installed status of the remote OWS, left, and display in the middle OWS, right.

2.4.2.5. Operating status of the road warning device and the OWD in the Level crossing

The device to record the operating status was equipped to the OWD in the Level crossing. According to the records in the device, the information were recorded that the road warning device started the warning operation about 48 seconds before the arrival of the Train at the Level crossing, and had detected the obstacle about 4 seconds after the road warning device started the warning operation.

2.4.2.6. Image records of the Level crossing

The surveillance camera for level crossing is installed in the Level crossing and recorded the status around the level crossing.

According to the records of the surveillance camera at the time of the occurrence of this accident, *hereinafter referred to as "the image records"*, the crossing gate in left side facing the level crossing started the operation about 41 seconds before the arrival of the Train at the Level crossing. Similarly, the crossing gate in right side facing the level crossing started the crossing operation about 32 seconds, and completed it about 26 seconds before the arrival of the Train at the Level crossing, respectively.

As for the situation from before the Truck started to enter the Level crossing from the Urashima route 152 to the Train collided with the Truck, the Truck entered from right side of the Level crossing about 63 seconds before the collision, and hindered the up line about 56 seconds before the collision. One of the two company staffs A and B who happened to be there, went around to the backward of the Truck at about 53 seconds before the collision.

Nextly, the crossing gate of the Level crossing started the operation about 41 seconds before the collision. After that, the Truck continued to cut wheel repeating to move forward and backward, and hindered the up line when the operation the crossing gate had completed. Furthermore, the Truck moved forward in the Level crossing, and hindered the down line, where the Train was running, about 7 seconds before the collision, and stopped on the down line in the level crossing about 3 seconds before the collision. Although the Truck moved

forward again about 1 second before the collision, because the Truck hindered the route of the Train, the front head of the Train collided to the left side of the load-carrying platform of the Truck.

The device recorded the situations after the collision as follows. The Truck was pushed in the direction of the Train, and the load-carrying platform was broken and the loaded freights were scattered on the railway track. The overhead contact lines had been damaged. The mast suspending the overhead contact lines, etc., planted in Nakakido station side of the Level crossing had been collapsed and tilting. The rear bogie and its periphery of the 3rd vehicle of the Train was running swirling up a cloud of sand and dusts and tilting to left when passed the Level crossing.

2.4.2.7. Outline of the operation of the level crossing protection device in the Level crossing

The Implementing Standard for Railway Electric Facility, one of the implementing standards notified by the Company to the Director General of the Kanto District Transport Bureau, *hereinafter referred to as "the Reported Implementing Standard"*, based on the "Ministerial Ordinance Providing for the Technological Standard for Railways", Ordinance of the Ministry of Land, Infrastructure, transport and Tourism, No.151 of 2001, *hereinafter referred to as "the Ministerial Ordinance for Technological Standard"*, prescribed on the operation of the level crossing protection device and the obstruction detecting device for level crossing as follows.

Article 116. The crossing gate should operate as prescribed in the followings.

(1) The crossing gate for level crossing should be composed of the warning device and the barrier device, and should operate automatically by the train.

(2) [Omitted]

(3) The time required from the start of warning to the completion of the blocking operation was 15 seconds as the standard. In this case, the time should be above 10 seconds.

(4) Concerning the machine, equipped with the crossing rods in both sides of the road, the crossing rod in right side toward the level crossing should start its operation after the crossing rod in left side toward the level crossing lowered completely, as the principle.

(5) The time after completed the operation of the cross rods to the arrival of the train should be 20 seconds as the standard, and 15 seconds as the minimum. Provided that, this regulation may not be applied for the case that the safety is secured until just before the departure of the train, etc., in the level crossing just next to the station controlled by the departing signal, etc.

(6) The time from the start of the warning alarm to the arrival for each train and the vehicles should not differ significantly by the velocity of the Trains, etc.

(7) The machine should start to release the blocked status after the train, etc. had passed.

(8) [Omitted]

Article 122. The automatic obstruction detecting device in the obstruction warning device for

level crossing should conform to the following standards.

(1) [Omitted]

(2) When the train approached to the level crossing and the automobile, except for the two-wheeled vehicle, etc., hindered the level crossing for a certain time continuously, the device should detect the auromobile automatically by the lights or the electromagnetic waves, etc., .

(3) The detection of obstruction should implement for the automobile, except for the two-wheeled vehicle, etc., in the structure gauge on the level crossing, as the principle.

(4) After detected the hindrance, cancel the detected hindrance status automatically when the hindrance had dispelled.

(5) The machine should not indicate the train, etc., passing the level crossing, as the obstruction, in the display device.

2.4.2.8. Outline of operation of the obstruction warning signal, OWS

The Implementing Standard of Railway Electric Facility, one of the Reported Implementing Standards, prescribed on the OWS as follows.

Article 81. The special signal should indicate the signal when it is necessary to stop the train specially in the unexpected place, and the kinds and the methods of indication should be as follows.

(1) The kinds of the special signals should be as follows.

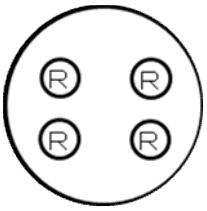
a. Fusee signal	*Indicate the stop signal by the flame*
b. Flashing light signal	*Indicate the stop signal by the flickering lamps*
c. Alarm signal	*Indicate the stop signal by the intermittent alarm sound and the flickering lights.*

(2) The indicating methods of the special signals should be as follows.

a. Fusee signal	*Red flame of the fuse*
b. Flashing light signal	*Four flickering red lamps of the flashing light signal*
c. Alarm signal	*Intermittent alarm sound of the train protection radio and the flickering red lamps*

Article 82. The device to indicate the fusee signal and the flashing light signal should be planted in the positions where the approaching train can confirm the signals from the position in the distance beyond that the approaching train can stop before the place where the route of the Train was hindered.

Article 83. The composition of the indicating device of the flashing light signal device should be as shown in the following.



Remarks 1. The flashing light signal device flicker 4 lamps simultaneously in about 60 to 100 times per minute.

2. "R" should be the red lamp

3. Diameter of the circle should be 600 mm as the standard

4. Diameter of the lamps should be 150 mm as the standard

5. Spacing between centers of the lamps should be 250 mm as the standard

In addition, the Implementing Standard of Handling Operation, one of the Reported Implementing Standards, prescribed the obstruction warning signal as follows.

Article 180. Method of indication of the special signals should be as follows.

Kind of special signal	*Kinds of indicated signal*	*Method of indication*
Fusee signal	*Stop signal*	*Red flame of the fusee*
Flashing light signal	*Stop signal*	*Flickering 4 red lamps in the flashing light signal device*
Alarm signal	*Stop signal*	*Intermittent alarm sound by the train protection radio and the flickering red lamps*

[Notes] The shape of the obstruction warning signal should be as follows.

Remarks *The flashing light signal flicker 4 lamps simultaneously in 60 to 100 times per minute.*

Sizes *Diameter of circle should be 600 mm or 480 mm*

Diameter of the lamps should be 150 mm or 120 mm

2.4.2.9. Procedures to install the obstruction warning signal device, OWS

As described in 2.4.2.8, the Article 82 of the Implementing Standard of Railway Electric Facility prescribed that "the device to indicate the fusee signal and the flashing light signal should be planted in the position where the approaching train can confirm the signals from the position in the distance beyond that the approaching train can stop before the place where the

route of the Train was hindered". According to the Company, the procedures on the installation of the OWS before the occurrence of this accident were as the following (1) to (4).

(1) Estimate the position in the maximum sighting distance required to conform to the Ministerial Ordinance for Technological Standard and the approved model specification of the ministerial ordinance, by working out on paper, considering the running velocity in the control section of the level crossing.

(2) Select the position to plant the OWS, where the flashing light signal device can be confirmed from the most distant place, at site, in the presence of the staffs relevant to the train operation.

(3) Select the place in the protection area of signal, *i.e.*, the level crossing side, where it is sighted from the planted position of the OWS determined in the above (2).

(4) Repeat the step (3) in turns, and install up to the neighborhood of the level crossing.

Additionally, there was no material prescribed, *i.e.*, clearly written, except for the above implementing standards, before the occurrence of this accident.

According to the Company, in case of the Level crossing, the maximum operating velocity in the section, including the Level crossing, is stipulated as 120 km/h in the "Implementing Standard of Handling Operation" described in the following paragraph 2.8.1. According to "the works standard of the driver of electric railcar, the internal rule" of the Company, the standard braking distance[*12] against 120 km/h, *i.e.*, 517.5 m, is considered as "the distance that the approaching train can stop before the place hindered the route of the Train", and stipulated that the OWS should be sighted from the place where the distance to the level crossing is over 517.5 m. In addition, according to the Company, the remote OWS of the Level crossing had been planted as to be sighted from about 570 m before the Level crossing.

*12 *"Standard braking distance" in this context is the braking distance calculated for the 2000 series vehicle of the company in the empty and dry conditions.*

2.4.3. Information on the visibility of the remote OWS of the Level crossing

2.4.3.1. Confirmation of the sighting status of the remote OWS of the Level crossing from the track

The sighting status of the remote OWS was confirmed from the edge of the platform for down line of Koyasu station, at 19,398 m, around the sighting position of the signal for the remote OWS of the Level crossing described in 2.4.2.9, and then the flickering status could be confirmed as shown in Figure 6. Additionally, the confirmation of the sighting status was implemented in the status that the railway accident investigator was watching on the sleeper around the left rail, where the eye height was about 1.6 m above tail surface, while the remote OWS was indicating the stop signal, *i.e.*, flickering, on the day of the occurrence of this accident.

Figure 6. Sighting status of the remote OWS on the accident day

2.4.3.2. Investigation of sighting status of the OWS of the Level crossing from the platform of Koyasu station

On November 2019, after this accident, the sighting status of the remote OWS of the Level crossing was investigated from the edge in the direction to Kanagawa-shimmachi station of the platform of down line of Koyasu station around the position, at 19,398 m, where the status of the remote OWS of the Level crossing could be confirmed as described in 2.4.3.1.

As shown in Figure 7, the display part of the remote OWS in the turned off status of the lamps could be sighted from the platform through the gaps between poles, etc., installed in the main tracks and the depot lines, etc.

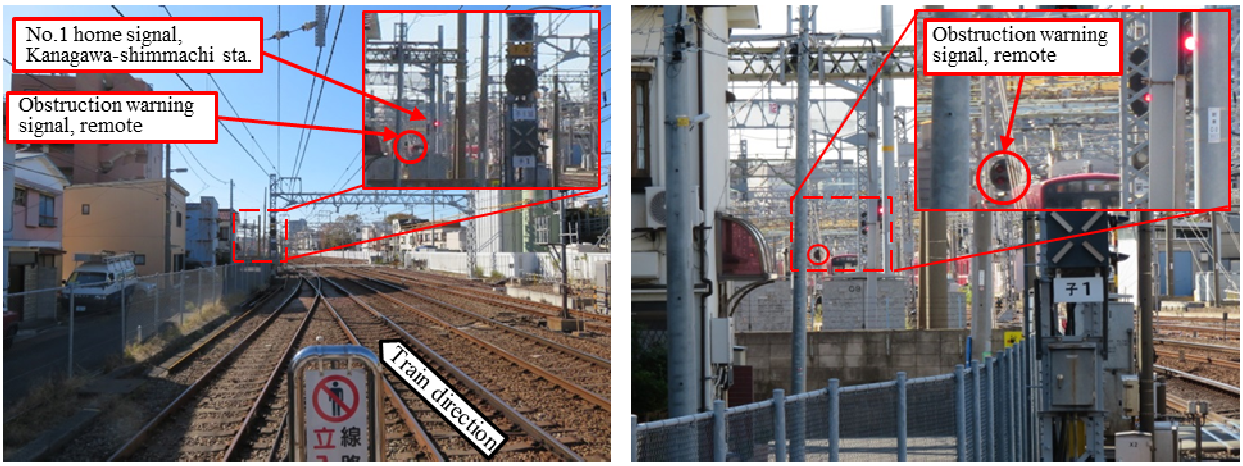


Figure 7. Sighting status of the remote OWS from the platform of Koyasu station

2.4.3.3. On-board investigation *[Refer to Attached Figure 3]*

In October 2019, after this accident, the Japan Transport Safety Board, the JTSB, investigated the sighting status of the signal indication when the train was approaching. In

detail, the railway accident investigator got on the nighttime out-of-service train, which was operated after the last train, running from Koyasu station toward Kanagawa-shimmachi station, and he investigated the status as indicating the stop signal in the OWS of the Level crossing, from around the driver's seat of the train.

The investigation was implemented as it was informed beforehand to the driver of the train that the OWS was indicating. In addition, the video camera was attached in right side of the driver's seat at about eye level height of the driver, the results of the investigation were as follows.

(i) The first image that recorded the status indicating the stop signal, *i.e.*, flickering, of the remote OWS, was just after the front head of the out-of-service train passed the edge of the down line platform of Koyasu station, around 19,398 m.

(ii) After the train passed the place described in (i), there were the scenes that the flickering status of the remote OWS was blocked, intermittently although it was an instant, by the lamp responding operation of the barrier machine of Koyasu No.1 level crossing installed in the mast suspending the overhead contact lines, the mast, etc., planted in between the red flash lamps of the road warning device of the Level crossing and the remote OWS of the Level crossing.

(iii) The position where the driver of the train operated the braking handle when henoticed the indication of the stop signal in the remote OWS, was Koyasu station side from the Koyasu No.1 level crossing, at 19,459 m. and it was at about 45 m ahead, from the place where the first image of indicating stop signal in the remote OWS was recorded as described in (i), converting into time, about 4 seconds after. In addition, the velocity when implemented the braking operation was about 40 km/h.

2.4.4. Methods and History of the inspection on the level crossing protection facility of the Level crossing

The Company has been implemented the inspection of the level crossing protection facilities periodically, and the road warning device and the crossing gate were checked on the operating status, etc., once a year. The periodic inspection of the Level crossing just before the occurrence of this accident was conducted in January 2019, and there was no abnormal situation in the record of the inspected results.

In addition, the Implementing Standard of Railway Electric Facility of the Company prescribed the inspecting items for the OWS as follows.

Facility name		*Standard period*	*Inspecting items*	*Remarks*
Level crossing	*Flashing light signal device*	*1 year*	*1. Quality of attachment and installed statuses*	

protection device		*2 years*	*1. Measurement of voltage of power source* *2. Propriety of sighting distance* *3. Measurement of flickering number*	

The sighting distance entered in the inspected results of the remote OWS of the Level crossing was "171 m". According to the Company, the required sighting distance calculated by the method described in 2.4.2.9, had been entered in the inspected results when the OWS for the Level crossing was installed.

As for the appropriateness of the sighting distance of the remote OWS of the Level crossing at the time of the inspection, setting the sighting position comprehended in advance as the check point, and whether the OWS in the off status can be sighted was checked from the check point, boarding on the running train mainly.

Additionally, the sighting distance of the remote OWS was entered as 171 m in the inspected records of the Level crossing, then the distance from the concerned sighting position to the edge in the origin of the Level crossing, around 19,965 m, was 562 m.

2.4.5. Information on the installed status, etc., of the obstruction warning device for level crossing, OWD

The railway and tramway operators are promoting to install the OWS in the level crossing, same as the OWD and the obstruction detecting system for level crossing, in order to improve safety of the level crossing, although they have not been prescribed as the duty to install in all level crossings.

According to "the number of level crossings in each category of operator and the number of level crossings equipped with the OWD" described in "the information on the safety of railway and tramway transportation, 2018" published by the Railway Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, the number of level crossings and the installed status of the OWD for the class 1 level crossing in each category of operator were as shown in Table 5.

According to the Company, the ratio of installation of the OWD was 100%, and the ratio of installation of the obstruction detecting device for level crossing was about 73%, as of September 2018, in the class 1 level crossings, total 86 places, of the Company.

Table 5 Number of level crossings and the installed status of the OWD in the class 1 level crossing for each category of operators, as of the end of March 2019

Category of operators	Class 1	Total including the other classes	Obstruction warning device for level crossing, OWD
JR, conventional line	18,336	20,182	15,200
Private railway, etc.	11,021	12,468	7,719
Major operators	5,291	5,320	4,995
Public operators	-	-	-
Small and medium	5,730	7,148	2,724

Streetcar	391	448	118
Total	29,748	33,098	23,037

* Data from "*Table 9. Number of level crossing in each operator and category of level crossing, as of March 2019*" in "Information on the safety of railway and tramway transportation".

2.5. Information on the vehicles

2.5.1. Information on the Train

Car classification	The 1000 type DC electric rolling stock, DC 1,500 V
No. of vehicles in trainset	8 vehicles
Passenger capacity of trainset	1,010 persons
Weight of the trainset	241.5 t[*13]
Brake type	All electric command type electromagnetic straight air brake combined with regenerative brake with load compensating device

*13 *[Unit conversion] 1 t = 1,000 kgw, 1 kgw = 1 kgf, 1 kgf = 9.8 N*

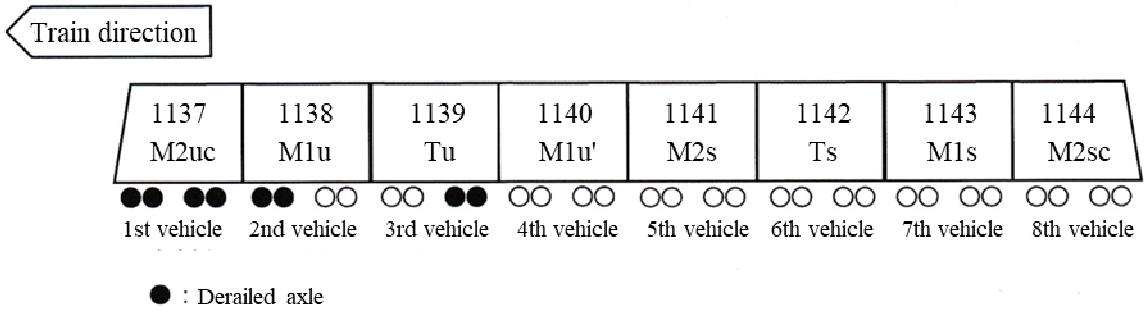


Figure 8. Trainset of the Train

2.5.2. Information on the inspection of vehicles

The Implementing Standard of Vehicle Maintenance, which is one of the Notified Implementing Standard, stipulates on the vehicle inspection, which is composed of the train inspection[*14], the monthly inspection[*15], the critical parts inspection[*16], the general inspection[*17], and they are implemented in every inspection period determined for each inspection respectively, or every determined running distance of the vehicles,. In addition, the extra inspection is implemented depending on the status of the vehicle.

The implemented status of the inspections of the Train just before the occurrence of this accident was as shown in Table 6. There was no abnormal situation in these inspected results.

Table 6. Implemented status of the inspections of the Train

General inspection	February 22, 2016
Critical parts inspection	September 20, 2018
Monthly inspection	September 3, 2019
Train inspection	August 28, 2019

*14 *"Train inspection" is the inspection of the major part of the vehicles in the on-condition status, implemented in every period not exceeded 10 days, in the company.*

*15 *"Monthly inspection" is the inspection of the status and the functions of the vehicles in the on-condition status, implemented in every period not exceeded 3 months, in the Company.*

*16 *"Critical parts inspection" is the periodic inspection on the major parts of the critical devices such as the power generating device, the running gear, the brake equipment, etc., implemented in every shorter period not exceeded 4 years or 600,000 km running distance, in the Company.*

*17 *"General inspection" is the periodic inspection on the whole vehicle implemented in every period not exceeded 8 years, in the Company.*

2.5.3. Information on the brake equipment of the Train

2.5.3.1. On the braking distance of the Train *[Refer to Attached Material 1]*

As described in 2.4.2.9, the OWS of the Level crossing is required to be confirmed from the position at over 517.5 m distant from the level crossing. According to the Company, the standard braking distance of 517.5 m was the value calculated by the estimating method of the standard braking distance using the values of the specification of the 2000 type vehicles of the Company. The braking distance for the 1000 type vehicle, which is the same type as the concerned vehicle, calculated by the similar conditions was 509.9 m.

2.5.3.2. Information on the test of the brake equipment of the Train

After this accident, the investigation was implemented for the items on the wheels and the brake equipment, etc., described in the followings. There was no trouble in the brake equipment and no abnormality such that the braking performance became to a factor related to the occurrence of this accident.

(1) Status of the wheel treads

(2) Confirmation of the pressure of the brake cylinder

(3) Thickness of the brake shoe and the gap between brake shoe and wheel

(4) Pressing force of the brake shoe

(5) Status of the rubbing surface of the brake shoe

2.6. Information on the damages and the traces of the railway facilities and the vehicles

2.6.1. Railway track and relations

There were the linear traces, considered as caused by the wheel flange, on the PC sleepers and the rail fastening devices, in the range started from the damages of the PC sleepers and the rail fastening devices inside gauge of right rail in around 19,930 m, *i.e.*, in the direction to Koyasu station, about 30 m before, the Level crossing, to the place where the 1st axle and the 2nd axle of the rear bogie of the 3rd vehicle stopped, and on the paved part of the track block in the Level crossing. Furthermore, there were the broken guard holders and the fallen off guard angles, about derailment prevention guard in the track beyond there.

In addition, there were the damages in the tiles in the edge of the platform for down line, the

main line side, of Kanagawa-shimmachi station, in the noise barriers, and in the turnout, etc.

2.6.2. Electric Facilities and Relations

The Shinkou No.1 column, at 19,979 m, supporting the overhead contact lines, etc., planted in the direction to Nakakido station of the Level crossing, had collapsed, and the Shinkou No.8 columns, at 20,023 m, had bent and damaged. The overhead contact line was broken and the support of the contact line was bent by the collapsed mast, etc.

In addition, the power distribution cables had been burnt and damaged by the spread fire of the Truck.

2.6.3. Status of Damages and Traces of the Vehicles *[Refer to Attached Figures 4 to 7]*

The major damages of the vehicle were as shown in the following (1) to (3), and there was no remarkable damage in the backward vehicles beyond the 4th vehicle.

(1) The 1st vehicle

The front window glass, the antenna of train radio, the air conditioner, the front skirt, the underfloor equipment, the end part of the vehicle body, etc., were damaged.

(2) The 2nd vehicle

The pantograph and the end part of the vehicle body were damaged.

(3) The 3rd vehicle

The glasses of right windows, the end part of the vehicle body, the rear part of left side surface, and the under floor equipment were damaged.

In addition, there were the traces considered as the contacts between the rear end of the 1st vehicle and the front end of the 2nd vehicle, between the rear end of the 2nd vehicle and the front end of the 3rd vehicle of the Train.

2.6.4. The Stopped Position and the Derailed Status the Train

The front head of the Train was halted in around 20,037 m.

The 1st vehicle halted as the vehicle body had been tilted to right, and all two axles in the front bogie had derailed to right. The rear bogie had derailed as ran onto the front part of the Truck, and stopped in the status as the Truck was stuck between the Train and the side wall, *i.e.*, the noise barrier, installed in left side of the track.

As for the second vehicle, left wheels of the 1st and the 2nd axles in the front bogie were status as floated about 10 cm from the tread of rail. Additionally, right wheels in the front bogie and all axles in the rear bogie were not derailed.

As for the 3rd vehicle, the 1st axle in the rear bogie derailed to left and deviated from rail by about 60 cm. In addition, the 2nd axle in the rear bogie derailed to left and deviated from rail by about 70 cm.

[Refer to Attached Figures 4 to 7]

2.7. Information on the Train Crews, etc.

2.7.1. The Distinction of Sex, the Age, etc.

The Driver was the 28 years old male, having the driver's license for Class A electric rolling stock issued on June 28, 2018.

The Conductor was the 27 years old female.

The Truck driver was the 67 years old male, having the driver's license of the large-sized automobile.

2.7.2. Working Records of the Driver

The working records of the Driver, from three days before the occurred day of this accident were as shown in Table 7.

Table 7. Working records of the Driver

	Monday, Sept. 2	Tuesday, Sept. 3	Wednesday, Sept. 4	Thursday, Sept. 5 <plan>
Attending	15:28	17:26	//	9:16
Leaving	23:06	//	8:41	<21:07>

* "//" indicates the night duty.

2.7.3. Physical Condition of the Driver

According to the records of the train operation aptitude test and the physical checkup of the Driver implemented in 2017, there was no abnormality including the eyesight.

2.8. Information on the Handling Operation

The Implementing Standard of Handling Operation, which is one of the Notified Implementing Standards of the Company, prescribed the maximum operating velocity, the operation of braking, the handling when the OWS was operated, etc., as follows.

2.8.1. The maximum operating velocity of the train including around the Level crossing

The Implementing Standard of Handling Operation of the Company stipulated the maximum operating velocity of the train between Shinagawa station and Yokohama station, including around the Level crossing, as 120 km/h.

2.8.2. Braking Operation of the Train

The braking operation of the train was stipulated as follows.

[Braking operation of train]

Article 23. The service brake should be operated when the driver stopped the train, as the principle. Provided that the emergency brake should be operated in the following cases.

(1) When the stop signal was indicated in the place where the train could not be stopped by the service brake.

(2) When the reasons that required to stop the train in a hurry, had happened.

2.8.3. Handling When the OWS is in Operation

The kinds of signals and the handling, etc., when the stop signal, included the OWS, is indicating, is stipulated as follows.

[Kinds of signals]

Article 132. Kinds of signals should be as follows.

(1) Fixed signal

(2) Signal for work site

(3) Hand signal

(4) Special signal

[Handling methods when the stop signal is indicating]

Article 133. When the stop signal is indicating, stop the train or the vehicle in approach of signal before the indicating place. However, when the stop signal indicates in the distance that cannot stop before the indicating place of the stop signal, or the special signal is indicating, stop the train or the vehicle promptly.

As mentioned in the above, the "Implementing Standard of Handling Operation" stipulated on the general braking operation for the train as "use the emergency brake when the cause had happened which requires to stop the train in haste", but on the other hand, also stipulated as "to stop the train promptly when the special signal is indicating", as described in 2.8.2. In addition, the "Work Standard of the Driver of Electric Railcar, bylaw" of the Company stipulated as "to stop the train promptly when the stop signal in the OWS is indicating". According to the Company, responding to these regulations, the driver stops the train by the service brake as the principle, and when the stop signal is indicated in the OWS, the driver is entrusted to judge which brake of the service brake and the emergency brake should be applied, considering the situation such as the velocity, the distance, etc., and the Implementing Standard of Handling Operation and the Working Standard of the Driver of Electric Railcar did not prescribe clearly on how to distinguish the brakes in their usage.

2.8.4. Information on the Regulation on the Stop Signal

The Ministerial Ordinance for Technological Standard stipulated on the indication of the signal to direct to stop as follows.

[Indication of signal to direct to stop]

Article 113. The trains, etc., should stop beforethe place to be stopped when the signal to direct to stop is indicating. However, the train should be stopped promptly when the signal to direct to stop the train is indicating in the distance where the train cannot stop before the position to be stopped and when the position to be stopped is not indicated.

2.9. Information on Weather Condition

The weather around the accident site at the time of the occurrence of this accident was clear.

2.10 The other information

The "Road Traffic Law", No.105, Law, 1960, stipulated on the passing through the level crossing by the cars including the Truck, as follows.

Article 33

1. *The car, etc., when trying to pass through the level crossing, should stop at just before the level crossing, if there was the stop line by the traffic sign, etc., stop at just before the stop line, the same shall apply hereinafter in this item, and should not move forward unless the driver confirms the safety. However, when conform to the signal indicated in the signal device, the cars, etc., can move forward without stopping at before the level crossing.*

2. *The car, etc., should not enter the level crossing, while the crossing rod of the level crossing started to closing or has been closed, or the road warning device of the level crossing is in warning operation, when the cars, etc., is trying to pass through the level crossing.*

3. *The driver, who becomes unable to drive the car, etc., in the level crossing due to the trouble or the other reasons, should take measures, such as to indicate the emergency signal, etc., immediately, to inform the staffs of the railway or tramway operator or the police men about the existence of the halting car, etc., in the level crossing due to the trouble or the other reasons, in addition to take measures required to move the concerned car, etc., to the place other than the level crossing.*

3. ANALYSIS

3.1. Analysis on the Derailed Status of the Train

The status of the derailment of the Train was as follows.

(1) As described in 2.4.2.6, in the image records of the Level crossing, the situations that the Truck hindered the route of the Train in the Level crossing, and the mast planted in Nakakido station side of the Level crossing collapsed and tilted after the front face of the Train collided with the left side of the load-carrying platform of the Truck, were recorded.

(2) As described in 2.3.1, there was the trace, considered as caused by the impact against the mast planted in Nakakido station side of the Level crossing, in the Truck.

(3) As described in 2.6.4, the 1st vehicle of the Train had been derailed in the status to run onto the front part of the Truck, and stopped in the status as the Truck was stuck between the side wall, *i.e.*, the noise barrier, installed in left side of the track and the Train.

(4) As described in 2.6.3, there were the traces considered as caused by the contacts between rear end part of the 1st vehicle and front end part of the 2nd vehicle, and between rear end part of the 2nd vehicle and front end part of the 3rd vehicle.

(5) As described in 2.6.1, there were the continuous traces, considered as caused by the wheel flange, on the PC sleepers and the rail fastening devices, from the place where the PC

sleepers and the rail fastening devices were damaged in the inside gauge of right rail around 19,930 m, *i.e.*, in the direction to Koyasu station of the Level crossing, to the place where the 1st axle and the 2nd axle of the rear bogie of the 3rd vehicle stopped, and on the paved part of the track block in the Level crossing. Furthermore, there were the broken guard holders of the guard angle and the fallen off guard angles, in the track beyond there.

Based on the above situations, it is likely that the process of the derailment of the Train were as follows. After the Train collided with the Truck halting in the Level crossing, and pushed the Truck, the 1st vehicle of the Train ran onto the front part of the Truck, and the vehicle body of the 1st vehicle became in the status as tilted to right and derailed. As for the 2nd vehicle, left wheels of the 1st axle and the 2nd axle in the front bogie rose upward due to the tilting of the 1st vehicle. As for the 3rd vehicle, the rear bogie rose upward due to being pushed from the following vehicles just as being collided from behind by the shock of the collision.

It is highly probable that this accident occurred at around 19,970 m in the Level crossing. The event recorder of the Train described in 2.1.2 recorded that the time of the occurrence of this accident was about 11:43, the running velocity of the Train at the time of the collision with the Truck was about 62 km/h.

3.2. Analysis on the operating status of the level crossing protection facility of the Level crossing

As described in 2.4.2.5 and 2.4.2.6, according to the operation records and the image records of the obstruction detecting device for the level crossing, the operated status of the Level crossing was as follows.

(1) The road warning device had started the operation about 48 seconds before the Train reached at the Level crossing. As for the crossing gate, the crossing gate in left side toward the level crossing started the operation about 41 seconds before, the crossing gate in right side toward the Level crossing started operation about 32 seconds before, and the closing operation had completed about 26 seconds before the Train reached at the Level crossing.

(2) The obstruction detecting device for level crossing detected the obstacle about 4 seconds after the road warning device started the warning operation described in the above (1).

Based on the above situations, it is highly probable that the road warning device, the crossing gate, the obstruction detecting device of the level crossing protection facility had been operated in accordance with the regulations of the Reported Implementing Standards of the Company described in 2.4.2.7.

3.3. Analysis on the obstruction warning signal, OWS, of the Level crossing

3.3.1. Analysis on the operation of the OWS of the Level crossing and position of the Train

The obstruction detecting device of the Level crossing detected the obstacle about 44 seconds before the collision as described in 3.2. The OWS was indicated when the obstruction detecting device for level crossing had detected the hindrance inside the level crossing as described in 2.4.2.4 (3). The Driver stated that he noticed the indicating stop signal of the OWS of the Level

crossing as described in 2.1.1 (1). Therefore, it is highly probable that the OWS of the Level crossing had been indicating the stop signal.

At this time, it is probable that the position where the Train was running at 11:42:39, was around 18,680 m, about 1,290 m from the Level crossing, based on the records of the event recorder described in 2.1.2.

3.3.2. Analysis on the position where the OWS of the Level crossing can be sighted

The most distant position, where the remote OWS of the Level crossing can be sighted from the down line main track where the Train ran, was around 19,398 m, about 572 m from the Level crossing. Based on the results of the on-site investigation, night time running test and the onboard investigation in daytime, as described in 2.4.3. Therefore, it is probable that the Train could sight the remote OWS when reached to around the above position.

3.3.3. Analysis on the status from the OWS starting operation to the braking operation

The actions until to the braking operation by the Driver were as follows.

(1) It is highly probable that the OWS of the Level crossing had been indicating the stop signal while the Train ran about 718 m long section, from the place of the Train when the OWS of the Level crossing started operation to the place where the Train can sight the remote OWS, *i.e.*, about 21 seconds when converting with 120 km/h, as described in 3.3.1. However, the system to notify the stop signal to the Driver was not existed.

(2) In order to stop the Train, running at about 120 km/h, before the Level crossing, the estimated emergency braking operation should be implemented within about 1.5 seconds for the standard braking distance 517.5 m, or within about 1.8 seconds for the braking distance of the 1000 type vehicle 509.9 m based on the calculating method of the standard braking distance, as described in 2.5.3.1. Therefore, it is probable that the time required for the driver to confirm the indicating signal had not been considered in the determination of the installing position of the remote OWS, installed based on the procedures for the installation described in 2.4.2.9.

(3) The number of flickering is 84 times per minute and the flickering period is about 0.71 sec, as described in 2.4.2.4. the Train cannot stop before the level crossing unless it operates the emergency braking operation while flickering about 2 times based on the trial calculation of the standard braking distance for the 2000 type vehicle, or while flickering about 3 times based on the trial calculation of the braking distance for the 1000 type vehicle.

(4) The supposed time from when the Train ran around the place, where the remote OWS of the Level crossing becomes to be sighted, to when the braking operation was implemented, was trial was about 4 seconds based on the records of the event recorder, as described in 2.1.2. Furthermore, the operation of the brake handle after notice of the stop signal indication was about 4 seconds after the train passed the place where the OWS could be sighted, even in the test running as the operation of the OWS was notified

beforehand, and different conditions such as the velocity, day and night, as described in 2.4.3.3.

(5) There was the scene that the flickering status of the remote OWS was blocked intermittently, although it was momentary, by the masts, etc., planted to the Level crossing, when the onboard investigation was implemented, as described in 2.4.3.3.

(6) The OWS is the device to indicate the stop signal when there is unusual status in the level crossing, and as described in 2.8.2, it is same as the fixed signal such as the block signal, etc. that the train takes the stopping operation when the stop signal is noticed. On the other hand, the OWS has the peculiarity to indicate the stop signal in the unanticipated timing such as the occurrence of troubles in the level crossing, etc., *i.e.*, the OWS has the property different from the fixed signal which the drivers confirm the signal indication from the determined position.

Based on these situations, it is probable that the driver could not operate the braking operation to stop the train before the Level crossing, at the position where the driver can confirm the operation of the OWS of the Level crossing.

It is likely that the braking operation could not be operated at the position where the driver can sight the operation of the OWS of the Level crossing, because the timing to notice the operation of the OWS became delayed concerned that it was difficult to respond immediately against the operation of the OWS of the Level crossing, which has the peculiarity to indicate the stop signal in the unanticipated timing, in addition, there were the scene as the flickering status of the remote OWS was blocked intermittently even in an instant by the masts, etc., in the route beyond the place where the OWS can be sighted, although the visibility for the OWA had been confirmed in the position where the remote OWS becomes to be sighted. .

3.4. Analysis on the braking operation by the Driver

The Driver operated the service brake at first at about 11:43:05, around 19,543 m, based on the records in the event recorder, as described in 2.1.2. The distance from the position of the Train at that time to the end edge in the direction to the origin of the Level crossing, around 19,965 m, was about 422 m. Therefore, it is highly probable that the service brake had operated after the Train ran for about 140 m from the position where the remote OWS became to be sighted, which was about 4 seconds converted into times.

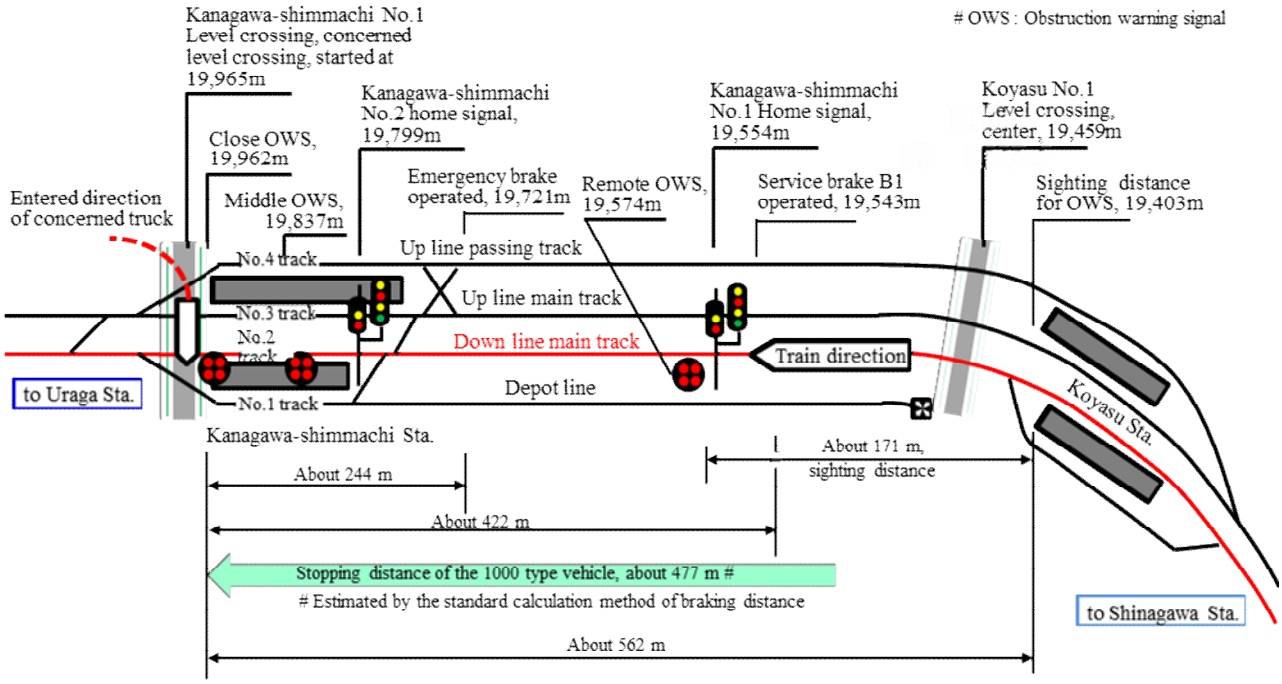
In addition, as described in 2.1.1 (1), the Driver stated that he confirmed the indication of the stop signal in the remote OWS and operated the service brake, therefore, it is probable that the service brake was operated as he noticed the indication of the stop signal in the remote OWS.

Furthermore, it is highly probable that the emergency brake had been operated, after the operation of the service brake, at about 11:43:11, around 19,721 m.

It is probable that the Driver noticed the operations of the middle OWS and the emergency informing device on the platform of Kanagawa-shimmachi station, after that, operated the emergency brake because he considered that the train could not stop before the Level crossing by the service brake, as described in 2.1.1 (1).

The distance from the Train described in the above to the end edge, in the direction to the origin, of the Level crossing, 19,965 m, was about 422 m. Furthermore, the braking distance by the emergency brake from the velocity 120 km/h excluded the idle running distance of the 1000 series vehicle was about 477 m by the trial calculation, as described in 2.5.3.1. Therefore, it is probable that the Train could not stop before the Level crossing, even if the Driver operated the emergency brake when he had operated the service brake.

It is likely that the velocity could be reduced at the time of collision if the Driver took the emergency stop procedures by the emergency brake promptly when he had operated the service brake. However, the Company stipulated to use the service brake when the driver stops the train as the principle, under the rule "when the special signal was indicated, stop immediately". And the Company had been entrusted the driver to judge which brake of the service brake or the emergency brake should be used when the stop signal is indicating in the OWS considering the velocity and the distance, etc. Therefore, it is likely that the above situation related with that the brake to be used had not been stipulated clearly in the implementing standard of handling operation and the working standard of the driver of electric railcar.



* This figure is the rough map showing the rough layout of the major facilities against the tracks, and the roads, based on the situation at the time of the accident investigation, and did not show in the correct reduction, the relative sizes, and the positional relationships.

Figure 9. Relationship between the braking operation of the Driver and visibility of the OWS

3.5. Analysis on the Brake Equipment of the Train

According to the test results of the brake equipment, there was no fault in the brake equipment and no abnormality as the braking performance related to cause of this accident, as described in 2.5.3.2.

Based on the operating status recording device, as described in 2.1.2., the deceleration in the

period from when the Train recorded the operation of the emergency brake at 101 km/h to when the suddenly reduced velocity was recorded at 62 km/h, which is considered as caused by the collision, was about 3.54.km/h/s, as the trial calculation. On the other hand, as described in 2.5.3.1, the deceleration from 101 km/h to 62 km/h for the 1000 series vehicle, which was the same series as the concerned vehicle, estimated by the trial calculation using the method to calculate the standard braking distance was about 3.54 km/h/s, as described in 2.5.3.1. Therefore, it is highly probable that the braking performance of the Train had been in the same level ability of the deceleration assumed by the Company.

3.6. Analysis on the status of the injured persons and the reduction of damages

It is probable that there were many injured persons, both the seriously injured persons and the slightly injured persons, in the vehicles from the 1st vehicle to the 4th vehicle, and injured by fall down and so on by the shock due to the collision of the Train and the Truck, as described in 2.2.1.

The passenger boarded on the 1st vehicle stated that he woke up just before the accident by the sound of whistle, and at the same time, the passengers in forward were moving to backward, and the passenger boarded on the 3rd vehicle stated that he did not noticed the whistle and the deceleration, as described in 2.1.1 (5).

The Conductor stated that there was the shock when she tried to pick up microphone of the public address system to guide the passengers that the train would stop suddenly, because she thought that the Train would stop suddenly by the rumbling of the alarm signal sound of the train protection radio, as described in 2.1.1 (2).

Based on the above situations, it is probable that there were some passengers who did not notice the train was going to stop suddenly. Therefore, it is likely that there is the possibility to expect the effects to reduce the injuries of the passengers by the collision by notifying passengers by the automatic guidance announcement linked together with the operation of the emergency brake when the train stops suddenly.

3.7. Analysis on the Truck

3.7.1. Analysis on the Route of the Truck to the Level Crossing

According to the representative of the trucking company, the Truck driver departed from the loading site at about 11:20, after loaded the freights, in the City of Yokohama. The Level crossing is not in the usual route from the loading site to the unloading site in Narita City. Therefore, he stated that he did not know the reason why the Truck passed the Level crossing, as described in 2.1.1 (4).

On the other hand, the Truck could not pass in the usual route because the Koyasu entrance of the metropolitan expressway, where the Truck had used usually for return trip, was closed by the repairing construction works of the toll gate in the Koyasu entrance on the day of this accident. Therefore, it is likely that the Truck passed the Level crossing via the Urashima route 152, in order to bypass the Koyasu entrance. But, the guide sign printed as "U-turn for the vehicle over height limit of 2.8 m" had been installed in left side of the road toward Nakakido station from

Kanagawa 2-chome intersection, as described in 2.4.1.2. However, it could not be determined the reason why the Truck used the route through the Urashima route 152, because the Truck driver was dead.

3.7.2. Analysis on that the Truck Entered the Level Crossing

It is certain that the Truck entered the Level crossing from right side of the Level crossing after it passed the Urashima route 152 and then the Urashima route 44 which intersects with the Level crossing, based on the image records, as described in 2.4.2.6.

According to the statements of the company staffs A and B, described in 2.1.1 (3) (ii) and (iii), the Truck driver tried to turn left, opposite direction to the Level crossing, at first, but he told to the company Staff A that he would turn right because it was difficult to turn left, after that, he tried to turn right. Therefore, it is probable that the Truck driver started to enter the Level crossing by turning right after he gave up to turn left due to judge that it is difficult to turn left.

Additionally, the road around the start point of the Urashima route 152 connected with the Urashima route 44 was the one-way road, as described in 2.4.1.2, and it was difficult to back the Truck physically because the Truck had been contacting with the traffic sign as described in the following 3.7.3. Therefore, it is likely that the Truck had been in the status that the Truck started to turn right could not return to Urashima route 152 by the backing operation.

3.7.3. Analysis on the handling operation of the Truck driver from the start of warning operation of the road warning device to the occurrence of this accident

It is highly probable that the road warning device of the Level crossing started the warning operation after the Truck had started to enter the Level crossing, based on the operated records of the Level crossing, as described in 2.4.2.5 and 2.4.2.6. It is certain that the Truck collided with the Train because the Truck had moved to the place where hindered the route of the Train, after that.

The Truck driver moved the Truck even after the blocking operation of the Level crossing had completed, as described in 2.4.2.6. As described in 2.1.1 (3) (ii), the company Staff A stated that after he heard the sound as something snapped when the Truck entered the Level crossing again, he moved to backward of the Truck and found that the Truck had contacted with the traffic sign. Soon after that, the road warning device of the Level crossing started the warning operation. Therefore, it is likely that the Truck driver had considered that it was hard to move the Truck backward and then moved forward in order to evacuate, *i.e.*, move to outside of the level crossing, but the reason could not be determined because the Truck driver was dead.

In addition, the road warning device of the Level crossing started the warning operation responding to the Train, the outbound train, approaching the Level crossing.

The indicator of running direction of the train installed in the column supporting the road warning device of the Level crossing indicates the running direction of the approaching train while the road warning device was in the warning operation, as described in 2.4.2.3 (3). Therefore, it is highly probable that arrow marks indicating the approaching of the outbound

train had been indicating at this moment, and it is probable that the running direction of the Train could be recognized from the position of the Truck driver halting in the Level crossing.

However, the Truck driver moved forward the Truck to the place hindering the route of the Train. Therefore, it is likely that the Truck driver moved forward the Truck because he could not understand the running direction of the Train, or, considered as necessary to move, evacuate, out of the level crossing although he had recognized the running direction of the Train. However, the reason could not be determined because the Truck driver was dead.

It is likely that this accident could be avoided if the company staff, who happened to be at the Level crossing, urged the Truck driver to move backward the Truck when the road warning device of the Level crossing started the warning operation. However, there was the risk to damage the traffic sign, the Truck and the neighboring building if urged to move the Truck backward forcibly, and the company staff had not understood the turning performance of the Truck. Therefore, it is considered as difficult that the company staff directed the Truck driver by instantaneous judgment whether the Truck could pass the Level crossing or not, or the method of evacuation.

3.8. Analysis on the structure of the road, the Urashima route 152

There was no traffic control on the sizes, such as the width and the length, etc., of the automobiles for the Urashima route 152, where the Truck ran just before reached to the Level crossing, as described in 2.4.2.6, and the Truck also was not restrained any traffic control.

On the other hand, the width of the Urashima route 152, around the place where connected with the Urashima route 44 that intersected with the Level crossing, was about 3.7 m, and the width between the traffic sign poles was about 3.3 m, *i.e.*, narrower than the width of the road, as described in 2.4.1.2. Then, the margin was only about 0.8 m because the width of the Truck was 2.49 m, as described in 2.3.1. In addition, the width of the Urashima route 44 was the same as the width of the level crossing, *i.e.*, about 11.1 m, around the place where connected with the Urashima route 152, as described in 2.4.1.2, on the contrary, length of the Truck was 11.99 m as described in 2.3.1. Therefore, it is probable that the Truck was required to start the turning action before the rear end of the Truck passed the traffic sign, when turned right or left from Urashima route 152. In addition, as described in 2.4.2.6, it is considered as difficult for the Truck to turn left or right in a short time, based on that the Track moved forward and backward for turning several times, and after that, the Truck contacted with the traffic sign when entered the Level crossing. Then, it is likely that the Truck spent long time to pass the Level crossing and caused to stay in the Level crossing, in this accident.

Therefore, from the viewpoints to aim the safe and smooth traffics, and to prevent the dangers in the road and the hindrance caused by the traffics, it is required for the road administrators and the public safety commissions of the prefectures, to study the measures such as to set up the traffic control on the width and the length, etc., of the automobiles, in order to prevent the situation from happening that the long and huge truck, such as the Truck, entered the route toward the Level crossing via the narrow road, such as the Urashima route 152..

4. CONCLUSIONS

4.1. Summary of the Analyses

The summary of the results of the analyses on this accident were as follows.

(1) The Truck halting in the Level crossing collided with the Train and pushed by the Train. It is likely that the 1st vehicle of the Train ran onto the front part of the Truck and derailed, and the left wheels in the front bogie of the 2nd vehicle rose up due to the tilting of the 1st vehicle, furthermore, the rear bogie of the 3rd vehicle rose up and derailed due to being pushed by the following vehicles which collided with the forward vehicles from behind. *[Refer to 3.1]*

(2) It is probable that the Truck driver reached to the Level crossing because he passed the route different from the usual route. It is likely that the Truck driver had tried to turn left, opposite to the Level crossing, initially, but started to enter the Level crossing by turned right because he judged that it is difficult to turn left. In addition, it is likely that the Truck driver passed the route different from the usual route related with that he could not operate in the usual route, and reached to the Level crossing as bypass via the Urashima route 152. However, it could not be determined the reason why the route different from as usual was used, because the Truck driver was dead. *[Refer to 3.7.1, 3.7.2]*

(3) It is highly probable that the road warning device of the Level crossing started the warning operation after the Truck started to enter the Level crossing. After that, it is certain that the Truck collided with the Train because the truck moved forward to the place where it hindered the route of the Train. In addition, it is likely that the Truck driver moved forward the Truck to move to outside of the level crossing considering as difficult to move backward, based on that he had tried to move forward the Truck after the blocking operation of the Level crossing had completed. However, it could not be determined the reason because the Truck driver was dead. *[Refer to 3.7.3]*

(4) It is highly probable that the road warning device started the warning operation about 48 seconds before the Train reached to the Level crossing. It is probable that the obstruction detecting device for the level crossing in the Level crossing detected the Truck about after 4 seconds after the warning operation was started and the OWS also started the operation. *[Refer to 3.2]*

(5) It is probable that the braking operation, to stop the Train before the Level crossing, could not implemented in the position where the driver became visible for the operation of the OWS of the Level crossing. It is considered as difficult to respond immediately for the OWS which has the peculiarity as to indicate the stop signal in the unanticipated timing. In addition, there were the scenes as the flickering status of the remote OWS was blocked

intermittently although it was instantaneously, beyond the position where the remote OWS became to be sighted, although the visibility of the remote OWS had been confirmed at the position where the remote OWS became to be sighted. Therefore, it is likely that the driver could not operate the braking operation to stop the train before the Level crossing, at the position where the operation of the OWS of the Level crossing could be visible, because the time to notice the operation of the OWS was delayed related with these situations. *[Refer to 3.3]*

(6) It is highly probable that the Driver operated the service brake at first at the position about 422 m before the end edge in the direction to the origin of the Level crossing, and operated the emergency brake after that at the position about 244 m before the Level crossing. It is likely that the velocity when the train was collided could be reduced if the Driver had operated the emergency stop procedures by the emergency brake when operated the service brake. However, the Company stipulated to use the service brake to stop the train as the principle under the rule "when the special signal was indicated, stop immediately". And the Company had entrusted the driver with the judgement to operate the service brake or the emergency brake when the stop signal was indicated in the OWS, considering the status such as the velocity, distance, etc. Therefore, it is likely that the above situation was caused related with that the brake to be used had not been prescribed clearly in the implementing standard of handling operation and the working standard of the driver of electric railcar. *[Refer to 3.4]*

(7) It is highly probable that the deceleration from the operation of the emergency brake to the collision showed that the braking performance of the Train had been in the same level ability with the deceleration assumed by the Company. In addition, there was no abnormal status, etc., in the brake equipment as to cause the factor that deteriorate the braking performance. Therefore, it is probable that the brake equipment of the Train had been acted normally. *[Refer to 3.5]*

(8) The width of the road was about 3.7 m and the span between the poles supporting the traffic signs was about 3.3 m, *i.e.*, narrower than the width of the road, around the place where the Urashima route 152, which the Truck passed just before it reached to the Level crossing, connected to the Urashima route 44. Therefore, it is likely that the Truck had been stayed in the Level crossing spending long time to pass the Level crossing, because the Truck was difficult to turn left or right in a short time. *[Refer to 3.8]*

4.2. Probable Causes

The JTSB concludes that the probable cause of this accident was certain that the standard sized truck entered the Kanagawa-shimmachi No.1 level crossing and hindered the route of the train, and the train could not stop before the Level crossing although the obstruction warning signal of the Level crossing had been indicating the stop signal, then collided with the Truck.

It is certain that the Truck hindered the route of the train because the road warning device started the warning operation after the Truck started to enter the Level crossing, and completed the

blocking operation before the Truck had passed through the level crossing, then the Truck stayed in the Level crossing.

It is likely that the Truck stayed in the Level crossing because it took long time for the Truck to pass through the Level crossing due to the narrow width of the road against the size of the Truck, when the Truck turned right in the intersection to enter the Level crossing.

As a side note, it is likely that the Truck driver selected the route to the Level crossing via the Urashima route 152 to bypass the usual route, related to that the Truck could not operate in the usual route. However, it could not be determined why the Truck passed the unusual route because the Truck driver was dead.

The train could not stop before the Level crossing, even though the obstruction warning signal of the Level crossing had been indicating the stop signal. It is probable that this situation was caused because the driver of the train could not implement the braking operation to stop the train before the Level crossing at the position, where the indication of the obstruction warning signal of the Level crossing became to be sighted from the driver of the train.

Concerning that the driver of the train could not implement the braking operation at the place where the driver became able to sight the operation of the obstruction warning device of the level crossing, it is probable that it was difficult for the driver to respond instantaneously to the OWS that has the peculiarity as indicates the stop signal in unanticipated timing. In addition, there was the scene that the flickering status of the remote OWS was blocked intermittently by the masts, etc. in spite of the place where the OWS became to be sighted. As a side note, it is likely that the velocity when collided could be reduced if the Driver had operated the emergency stop procedures by the emergency brake when he operated the service brake. However, the Company stipulated to use the service brake to stop the train as the principle under the rule "when the special signal was indicated, stop immediately". And the Company had entrusted the driver with the judgement to operate the service brake or the emergency brake when the stop signal was indicated in the OWS, considering the status as the velocity, distance, etc. Therefore, it is likely that the above situation was caused related with that the brake to be used had not been prescribed clearly in the implementing standard of handling operation and the working standard of the driver of electric railcar.

5. SAFETY ACTIONS

5.1. Measures to Prevent the Recurrence Considered as Necessary

The concerned standard sized truck reached to the Level crossing after passed the city road Urashima route 152 and turned right to the city road Urashima route 44. However, it is likely that the Truck stayed in the level crossing caused by that it took long time to pass the level crossing, because the width of the road was narrow against the size of the Truck, in this accident. Therefore, it is required for the road administrators and the Kanagawa prefectural public safety commission to implement the measures to prevent that the automobile, which is difficult to pass through, enter

incorrectly to the city road Urashima route 152, such as to set up the traffic control on the sizes, such as the width and the length of the automobiles.

The railway operators are required to take measures by the obstruction detecting devices, etc., if necessary, considering the velocity of the train, the traffic volume of the railway and the road traffic, kinds of the passing automobiles, etc., so it is necessary for the railway operators to implement these measures continuously. In addition, it is considered as difficult to respond immediately to the OWS, which has the peculiarity to indicate the stop signal in the unanticipated timing, in this accident. Therefore, it is necessary to install proper number of OWSs in the proper layout, considering the time required to the operation of the brake after the driver noticed the operation of the OWS in addition to the braking distance, in order to implement the certain braking operation at the place beyond where the train can stop before the hindered place.

In addition, it is likely that the velocity at the collision could reduce if the emergency brake procedure was implemented promptly by the emergency brake, in this accident. Therefore, it is desirable to decide the concrete handling on the basic methods of the braking operation, including the emergency brake, considering the installed status of the OWSs, and to implement the education and the training of the drivers, on the braking operation when they confirmed the indication of the stop signal of the OWS.

Furthermore, it is probable that braking operation could not be implemented to stop the train before the Level crossing, at the place where the driver became to be sighted the operation of the OWS of the Level crossing, in this accident. Therefore, it is desirable to implement the multifaceted studies on the system to back up the braking operation of the driver, such as the system to send the message to excite attention in the train, or to cooperate, or operate together, with the safety system such as the automatic train stop device, etc., in order to stop or decelerate the train promptly when the obstruction detecting device for level crossing had operated, as the measures to improve the safety still more, to prevent accident and reduce damages.

5.2. Measures Taken by the Railway Operators after the Accident

On September 2019, after this accident, the Company notified the change of the Working Standards of the Driver of Electric Railcar, an internal rule, to "stop immediately" on the handling of the brake when noticed the stop signal of the OWS. After that, the rule was changed as "operate the emergency brake procedures immediately" on November 2019. Furthermore the rule was changed as "when noticed the indication of the flashing light signal, operate the emergency brake immediately and stop the train, provided that the use of the service brake is allowed only when the train can stop certainly in approach of the confirmed flashing light signal, such as the train was operating in low speed as in the slowing down operation or there is enough distance until the noticed flashing light signal" on February 2020. At the same time, the Company implemented the education and the training for all drivers.

On December 2019, the Company reviewed the rules to install the OWS, and decided the installing position where the OWS can be sighted from the place in the distance that the margins are added to the conventional place, *i.e.*, "the place where the OWS can be sighted from the place

beyond the distance that train can be stopped by the emergency brake", in order to add still more the margins to brake operation and to improve the visibility of the OWS.

Additionally, the Company installed the additional OWS for the Level crossing on December 2019. In addition, the Company implemented the additional measures to install the OWS, for the other level crossings.

5.3. Measures implemented by the trucking company after the accident

Corresponding to the occurrence of this accident, the trucking company, for which the Truck driver was working, implemented the instruction to the drivers so that they select the proper route and operate the truck studying on the selection of the operating route in advance. In addition, the trucking company instructed for the drivers to contact with the police when the passage became in the difficult status.

5.4. Measures Taken by the Ministry of Land, Infrastructure, Transport and Tourism after the Accident

On September 9, 2019, the Automobile Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, the MLIT, responded to the occurrence of this accident, in order to prevent the recurrence of the similar accident, made commonly known the trucking operators in the whole country to enforce the followings in the roll call, the guidance, supervising for the drivers.

(1) Implement the required instruction to secure the safe operation of the automobiles for business purpose such as to select the route that can pass, to the drivers in the roll call.
(2) Instruct the drivers to implement the proper measures for protection against the trains by pushing the emergency push button, etc., when the automobile became unable to operate in the level crossing.
(3) Urge the drivers to select the proper operating route to avoid the route difficult to pass through, as the driver comprehended the operating route in advance, in the guidance and the supervising for the drivers.

In addition, the Automobile Bureau has been studying on the investigation and analysis of the factors to cause the accident related to the truck in this accident and on the measures to prevent the recurrence in the investigation committee for the accident of the automobiles for business purpose.

The Railway Bureau of the MLIT, responding to the measures of the Company against this accident to install the additional OWS and to review the braking operation when the OWS indicated the stop signal, let the railway operators in the whole country known well on the measures implemented by the Company, in order to make absolutely sure to secure the safety of the train operation and to prevent the recurrence of the similar accident, and instructed to review on the installed status of the OWS and on the handling when the drivers noticed the indication of the stop signal of the OWS, and to implement the measures depending on the necessity.

5.5. Measures Taken by the Road Administrator after the Accident

The road administrator, *i.e.*, Kanagawa Civil Engineering Office of the City of Yokohama, installed the guidance board to suppress the entrance of the large-sized automobiles and the guiding sign to indicate the bypass route around Nakakido station, *i.e.*, in the direction to end of the Urashima route 152, where the Truck had passed on the way to the Level crossing, as shown in Figure 10, in December 2019.

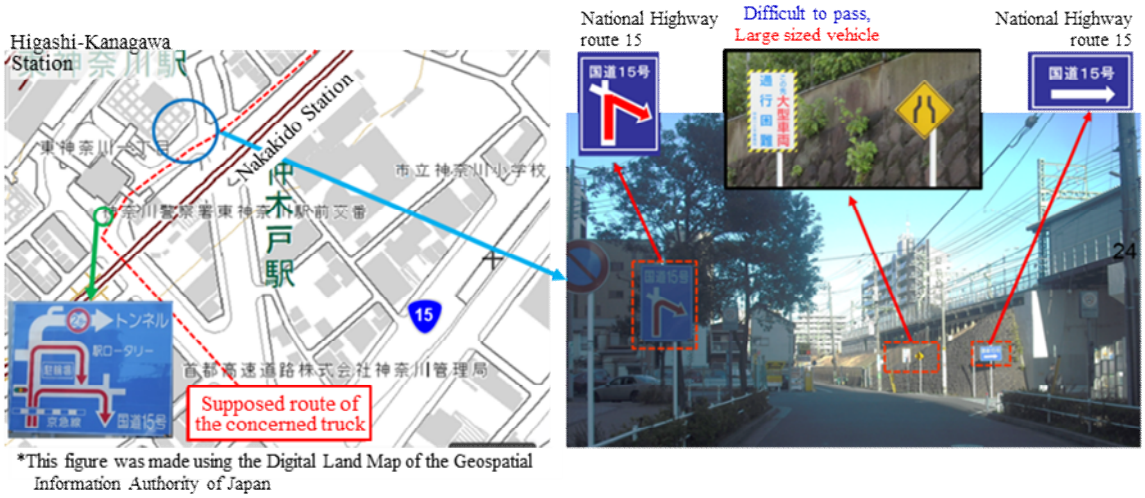
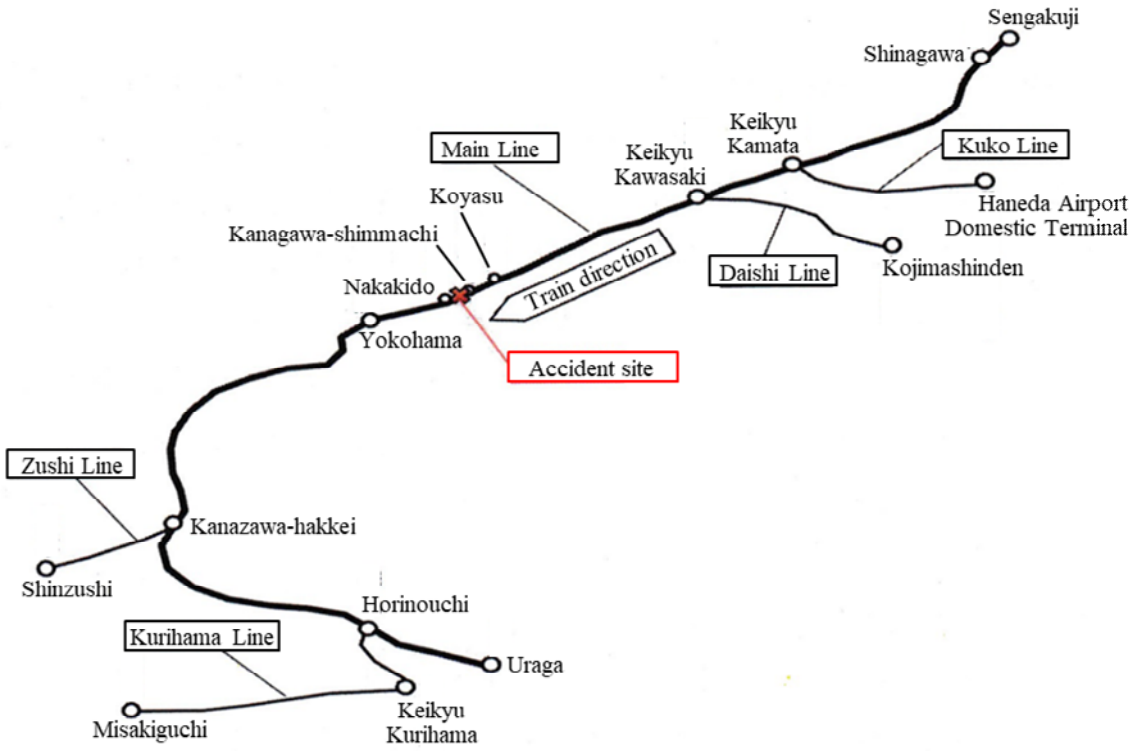


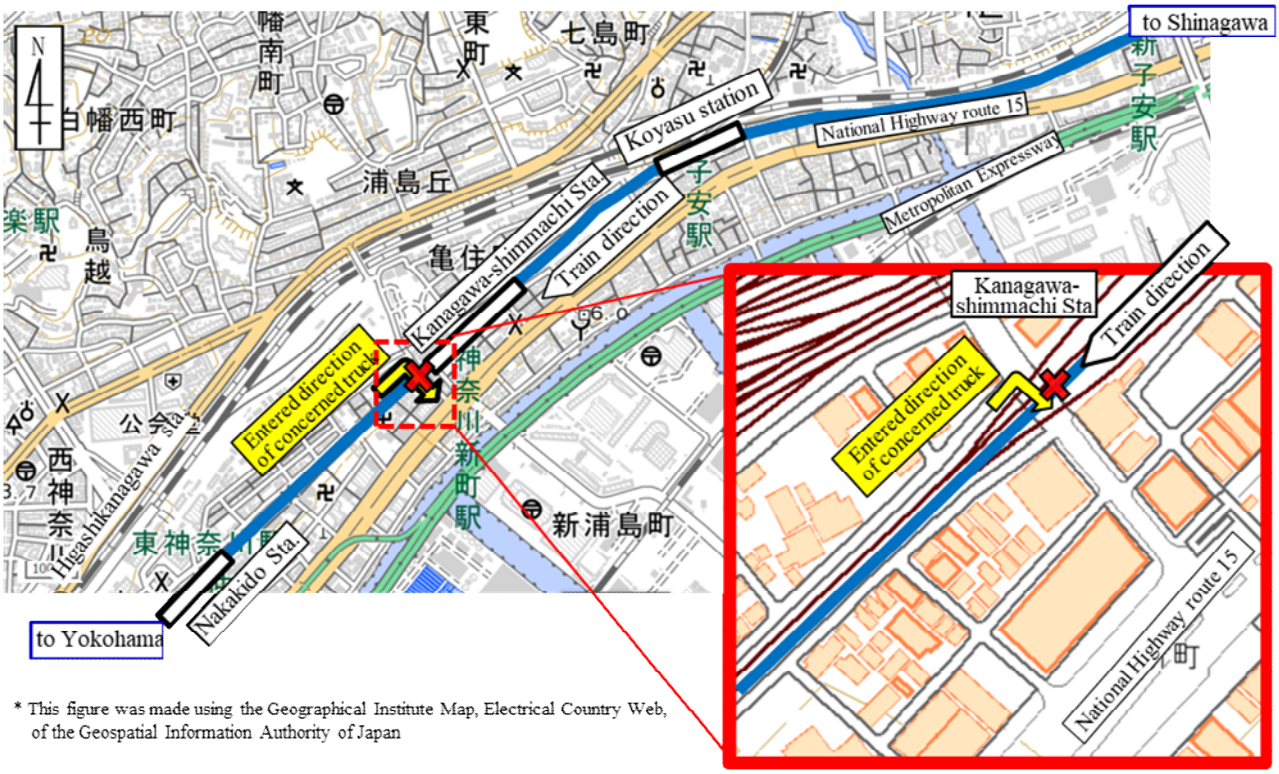
Figure 10. Installed status of guiding sign, etc., installed in around Nakakido station

Attached Figure 1. Route Map of the Main Line, Keikyu Corporation

Between Sengakuji station and Uraga station, 56.7 km, electrified double track, 1,435 mm gauge.

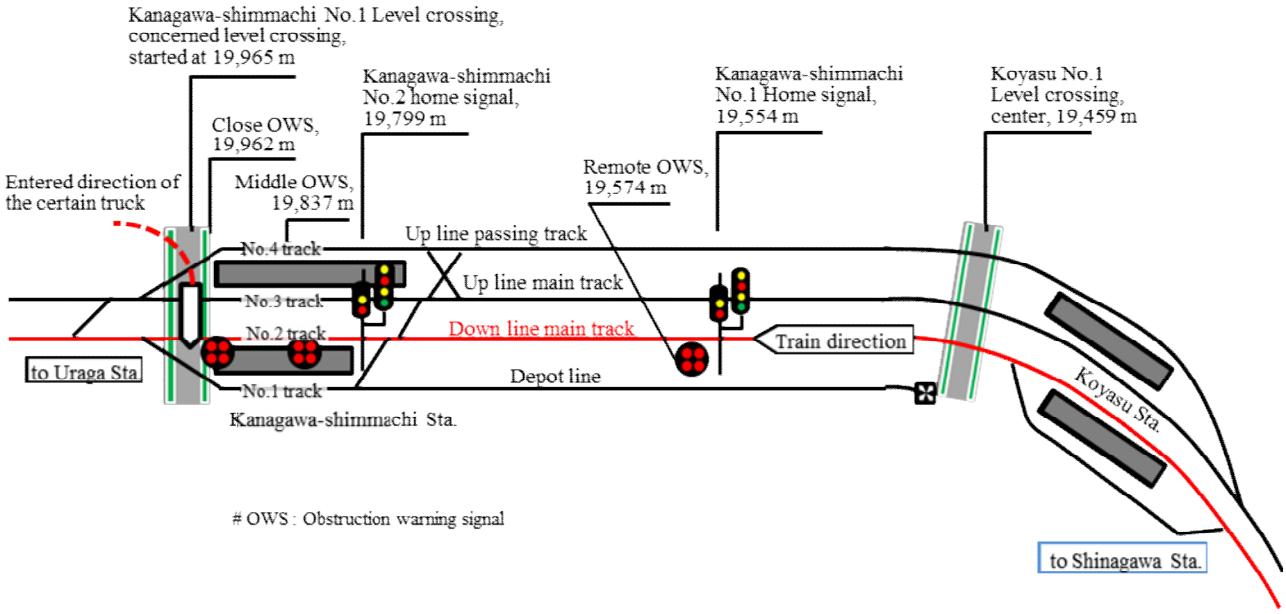


Attached Figure 2. Topographical Map around this accident site



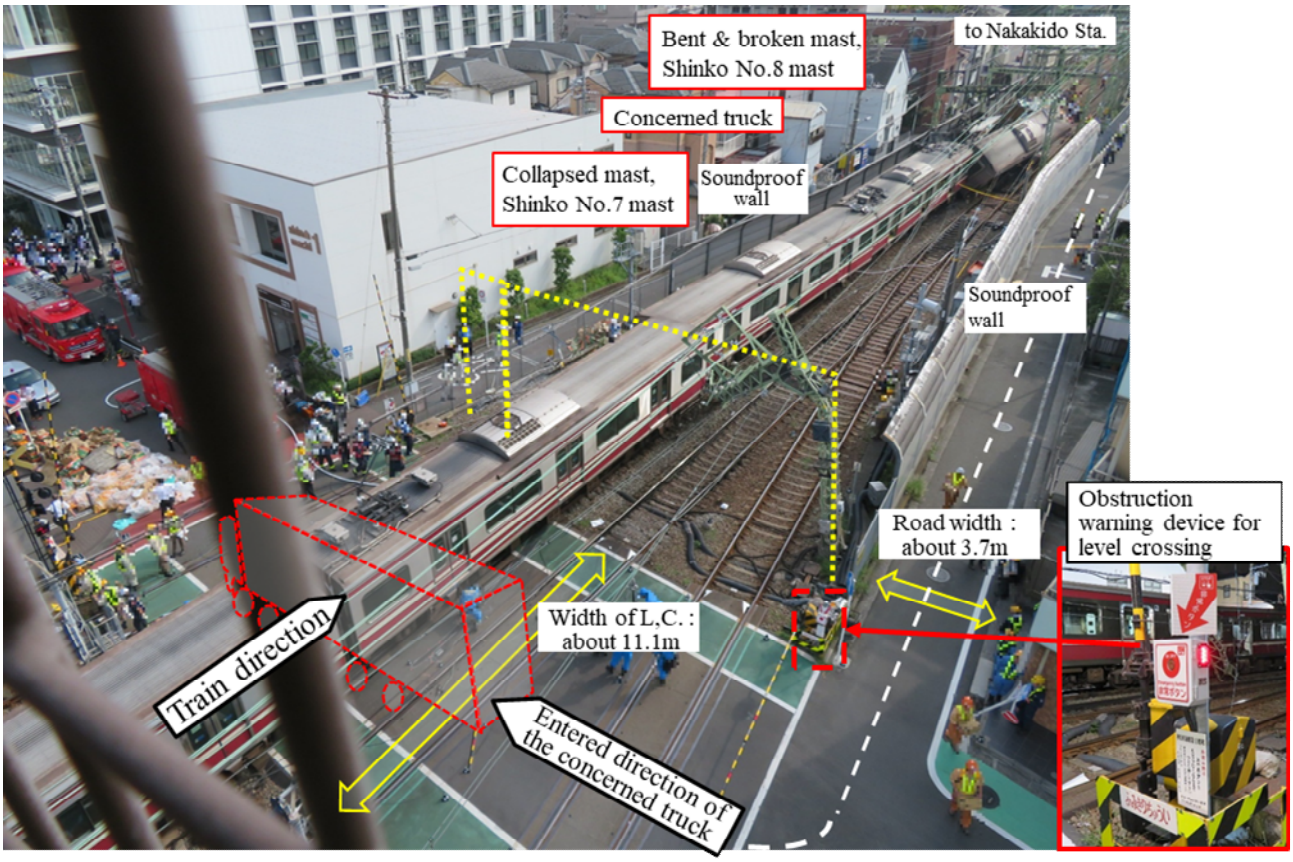
* This figure was made using the Geographical Institute Map, Electrical Country Web, of the Geospatial Information Authority of Japan

Attached Figure 3. Rough Map around the Accident Site

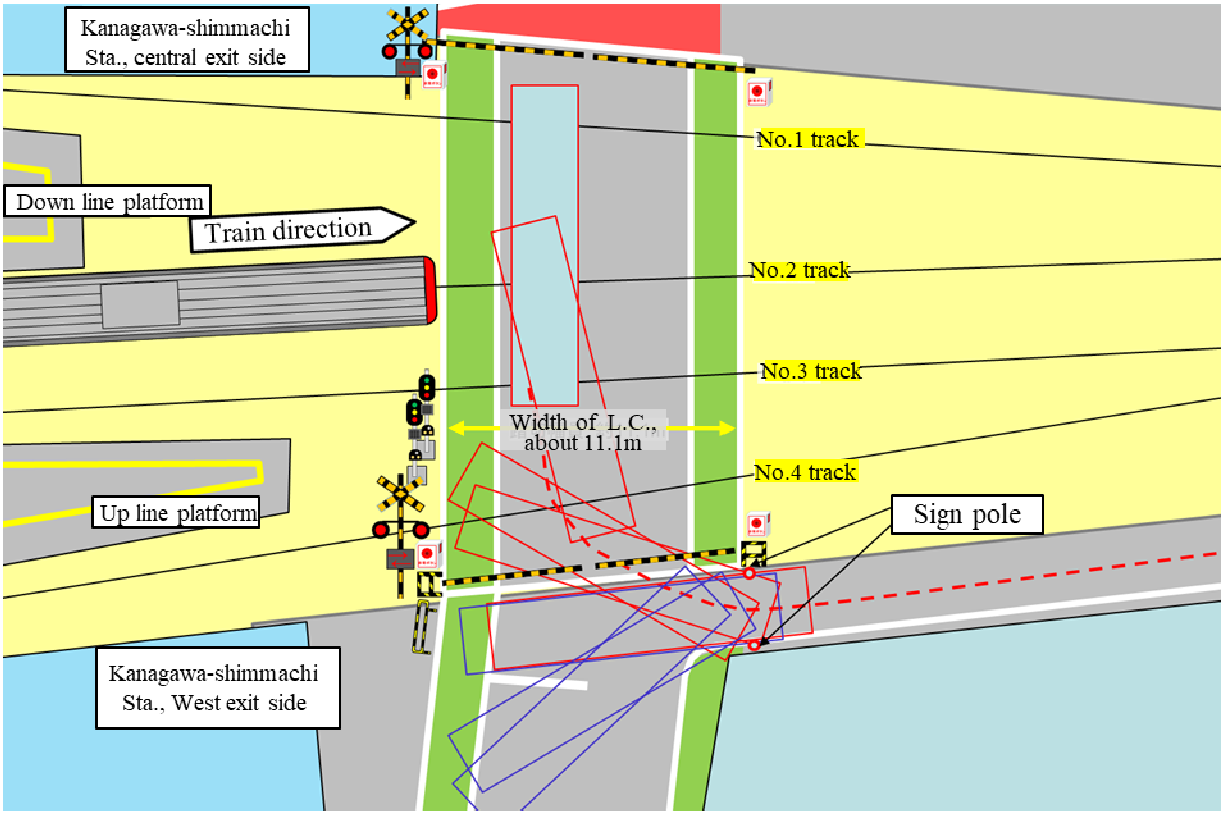


This figure is the rough map showing the rough layout of the major facilities against the railway tracks and the roads based on the status at the investigation of the accident, and does not show the correct scales, relative sizes, and the relative positions.

Attached Figure 4. Status of around the accident site

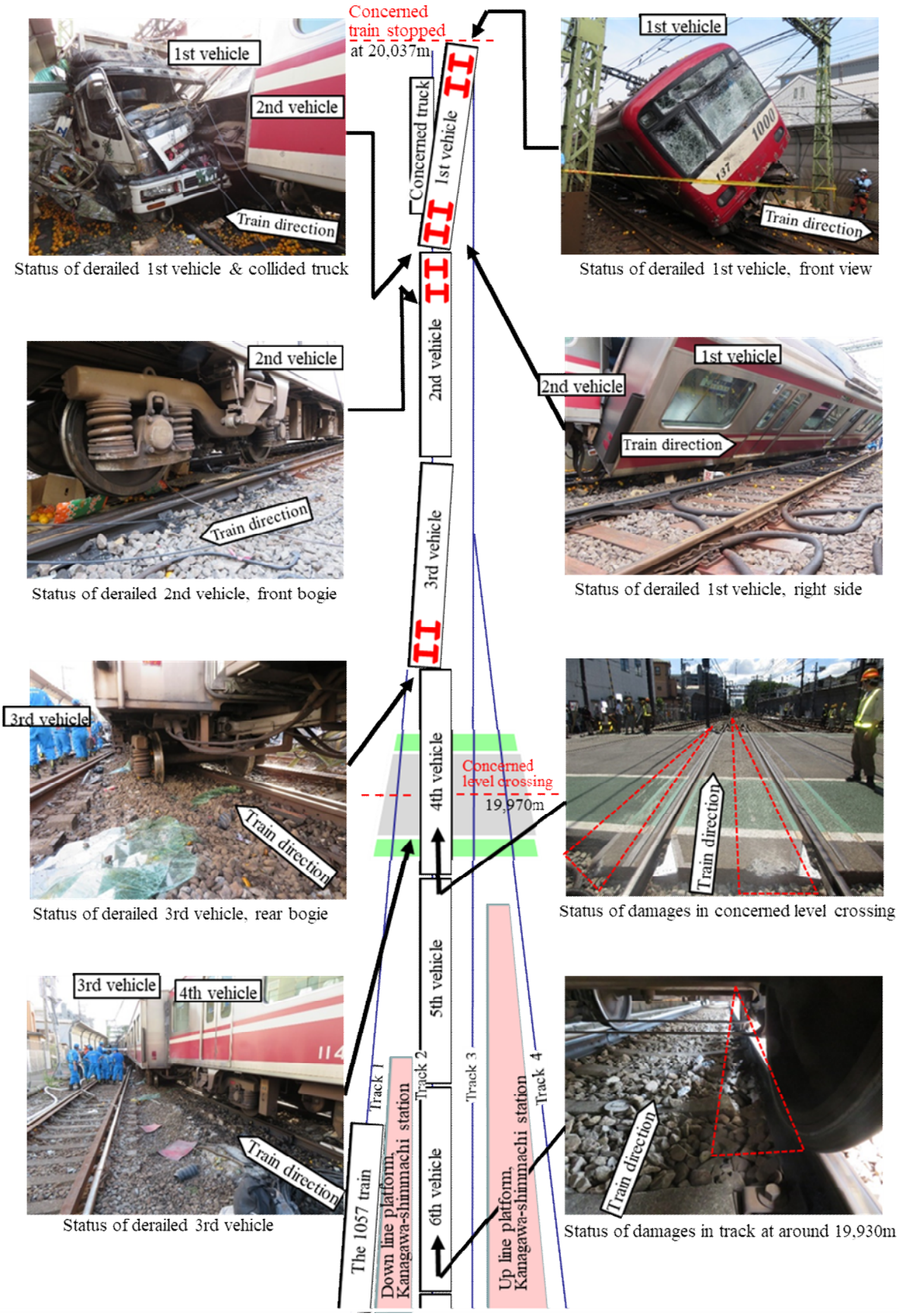


Attached Figure 5. Rough Map of the Status of Around the Accident Site

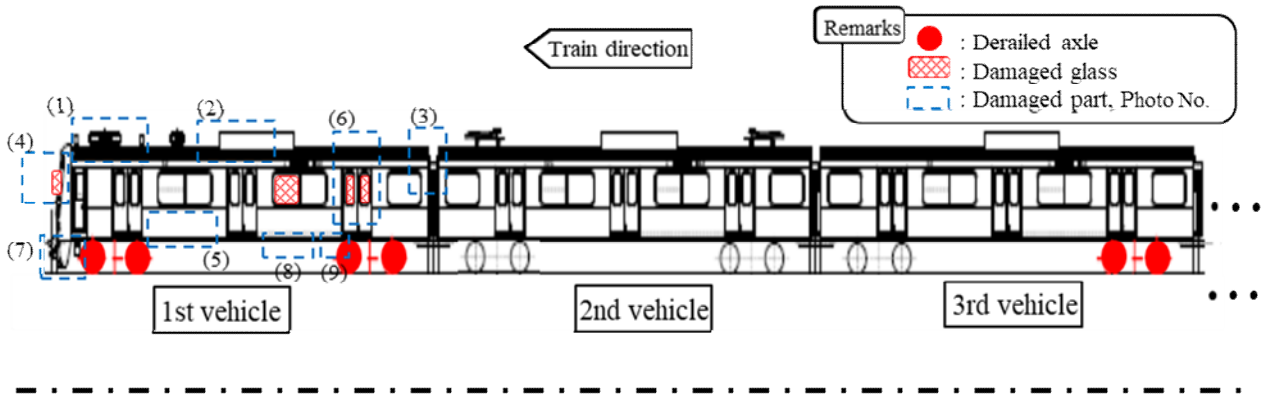


This figure is the rough map showed the rough layout of the major facilities against the railway tracks and the roads, and the turning traces of the Truck, based on the status at the investigation of the accident, and did not show the correct scales, relative sizes, and the relative positions. In addition, the turning traces of the automobile differed from the actual turning traces of the Truck.

Attached Figure 6. Rough Map of Around the Accident Site

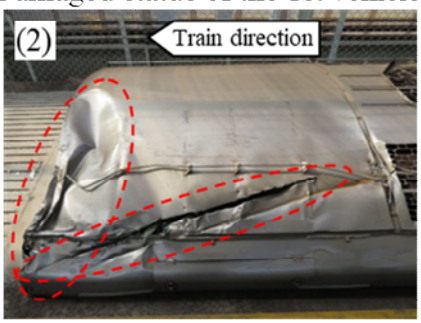


Attached Figure 7. Damaged Status of the Vehicle [1]

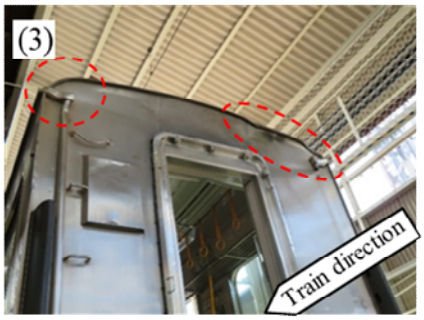


Damaged status of the 1st vehicle

Train radio antenna damaged.

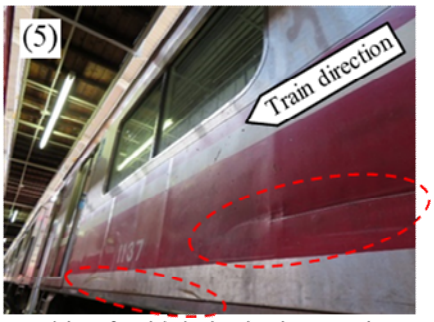


Air conditioner damaged.



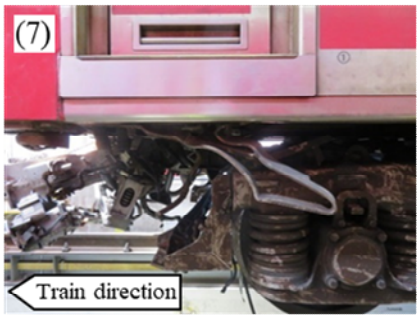
End of vehicle body damaged.

Glass in front window damaged.

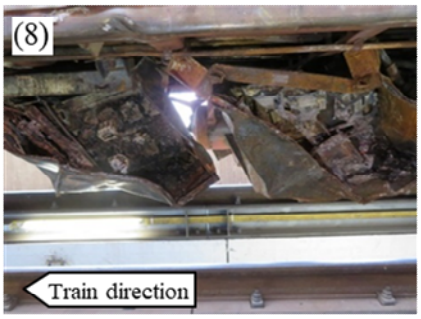


Side of vehicle body damaged.

Doors for passengers damaged.



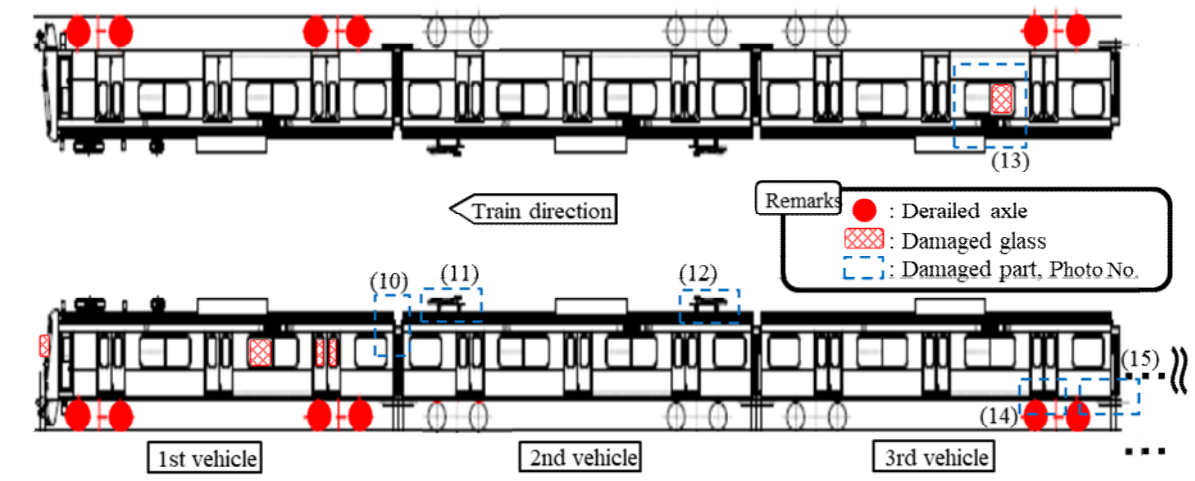
Front skirt damaged.



Underfloor apparatus damaged.

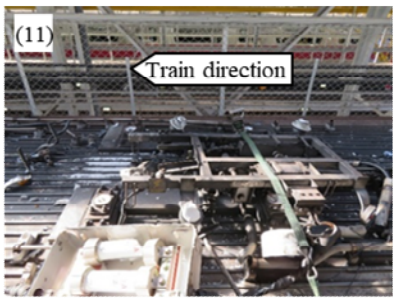
Underfloor apparatus damaged.

Attached Figure 7. Damaged Status of the Vehicle [2]



Damaged status of the 2nd vehicle

End of vehicle body damaged.

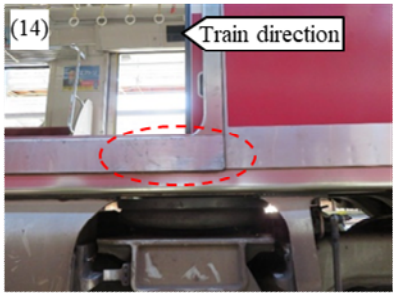


Pantograph damaged.

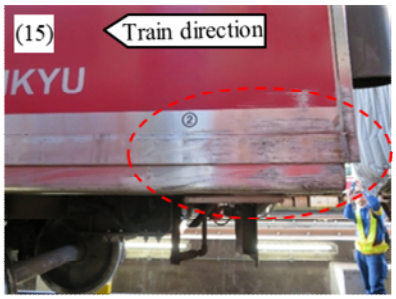
Pantograph damaged.

Damaged status of the 3rd vehicle

Glass in right window damaged.



Rear left side surface damaged.



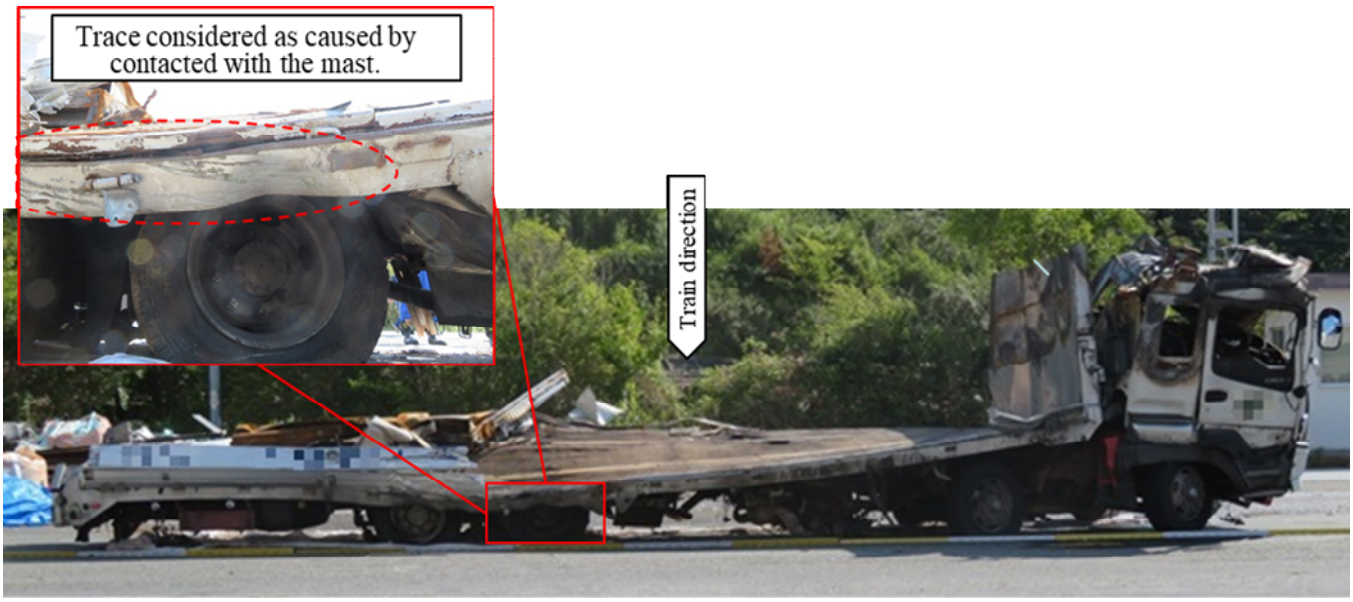
Rear left side surface damaged.

Attached Figure 8. Damaged Status of the Truck

Front view

Rear view

Left side view



Right side view

Attached Material 1. Method to Calculate the Standard Braking Distance

According to the Company, the standard braking distance is calculated in the following procedures.

Here, the standard braking distance 517.5 m was the value calculated based on the specifications of the 2000 series vehicle of the Company, and calculated as to set the pressure of the brake cylinder multiplied by 1.2, between 110 km/h to 20 km/h in the empty loaded condition. This condition supposed the operation of the increasing function of the emergency brake. In addition, the coefficient of friction was set as the coefficient for the dry condition, and changed depending on the velocity.

[1] Calculate the braking force in each vehicle b by the following equation.

$$b = \pi D^2/4\ P\ \tau\ \eta\ \mu\ n\ w \qquad \text{Eq.1}$$

Here, D [cm] is the diameter of the brake cylinder, P [kg/cm^2] is the pressure of the brake cylinder, τ is the ratio of the brake lever, η is the braking efficiency, μ is the coefficient of friction between wheel and brake shoe, n is the number of brake cylinders, and w is the weight, *i.e.*, the vehicle mass multiplies the coefficient of inertia.

[2] Calculate the deceleration β by the following equation.

$$\beta = (B\ 9.8) / (1000/3.6\ W) \qquad \text{Eq.2}$$

Here, B is the braking force for the trainset, *i.e.*, the sum total of the braking force for each vehicle b, W is the weight of the trainset, *i.e.*, the sum total of the weight of each vehicle w.

[3] Calculate the braking distance S by the following equation.

$$S = V_2 - V_1 / 7.2 / \beta \qquad \text{Eq.3}$$

Here, V_1 [km/h] is the initial velocity, V_2 [km/h] is the velocity after decelerated by 1 km/h, *i.e.*, $V_2 = V_1 - 1$, β [km/h/s] is the deceleration.

[4] After this, repeat the above (1) to (3) steps to calculate the braking distance for each 1 km/h, and sum up them. The total braking distance is obtained by added the idle running distance, corresponded to the idle running time 1 second, to the above summed up braking distances.