

Survey Report:

Fukuchiyama Line Train Derailment

Prepared by Editorial Office

We review a dramatic train derailment occurring at 09:18 on April 25, 2005, 1800 m from Amagasaki Station on the Fukuchiyama Line of West Japan Railways (JR West). The derailment killed 106 passengers and the train operator and injured over 500 passengers. Section 1 outlines the derailment, Section 2 details damage caused by the derailment, Section 3 reports information on crew activities, Section 4 describes the operator's actions leading up to the incident, Section 5, 6 relates train operation recorded by the Automatic Train Stop (ATS) devices and other safety systems, and Section 7, 8 gives information on train operation.

Keywords: Fukuchiyama Line derailment accident, Automatic Train Stop (ATS)

1. Overview

The derailment occurred at 09:18 on April 25, 2005, on the West Japan Railway Fukuchiyama Line 1800 m from Amagasaki Station in the direction of Doshisha Station. The up (direction of Amagasaki Station) rapid express 5418 m passed Tsukagoshi Station at 09:18:27, 1min17s behind schedule. When the front of the train hit a point 1949 m from Amagasaki Station at a 304 m radius curve, it began to derail at 09:18:54 near pillar No.41 1814 m from Amagasaki Station (Figs. 1, 2, 3, 5).

The first coach turned over, the front crashing into the wall of a condominium parking lot at the left side of the track and the lower rear of the coach crashing into a column northwest of the condominium. The left central section of the second coach crashed into a column northwest of the condominium, sandwiched between the rear of the first coach, with the left rear of the second coach crashing into a column northeast of the building.

The axles of the front bogie truck and all axles of the front bogie truck of the third coach were separated completely from the coach and thrown to the left of the railway tracks and the two axles of the rear bogie truck to the right (Fig. 5). All axles of the fourth coach were thrown to the right and two axles of the front bogie truck were thrown to the left, leaving the left wheels of the two axles of the rear bogie truck suspended in the air.

The sixth and seventh coaches did not derail. The rear of the train came to rest 1825 m from Amagasaki Station (Fig. 5).

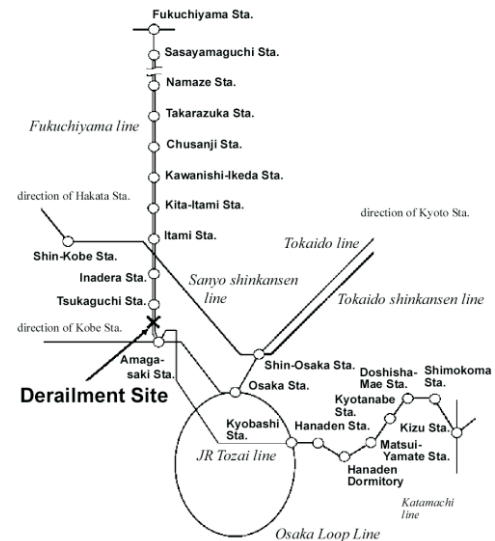


Fig. 1. Fukuchiyama line, length of Amagasaki Sta. to Fukuchiyama Sta. : 106.5 km. (Fukuchiyama line is double track line, except Shinoyamaguchi Sta. to Fukuchiyama Sta. which is single track line.)

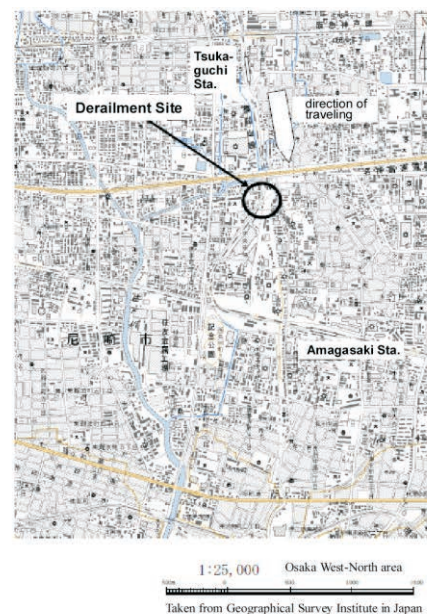


Fig. 2. Topographical map around derailment site.

2. Damage

2.1. Victims

The derailment killed 106 passengers and the driver (total: 107) and injured 555 (as of August 19, 2006) (Table 1).

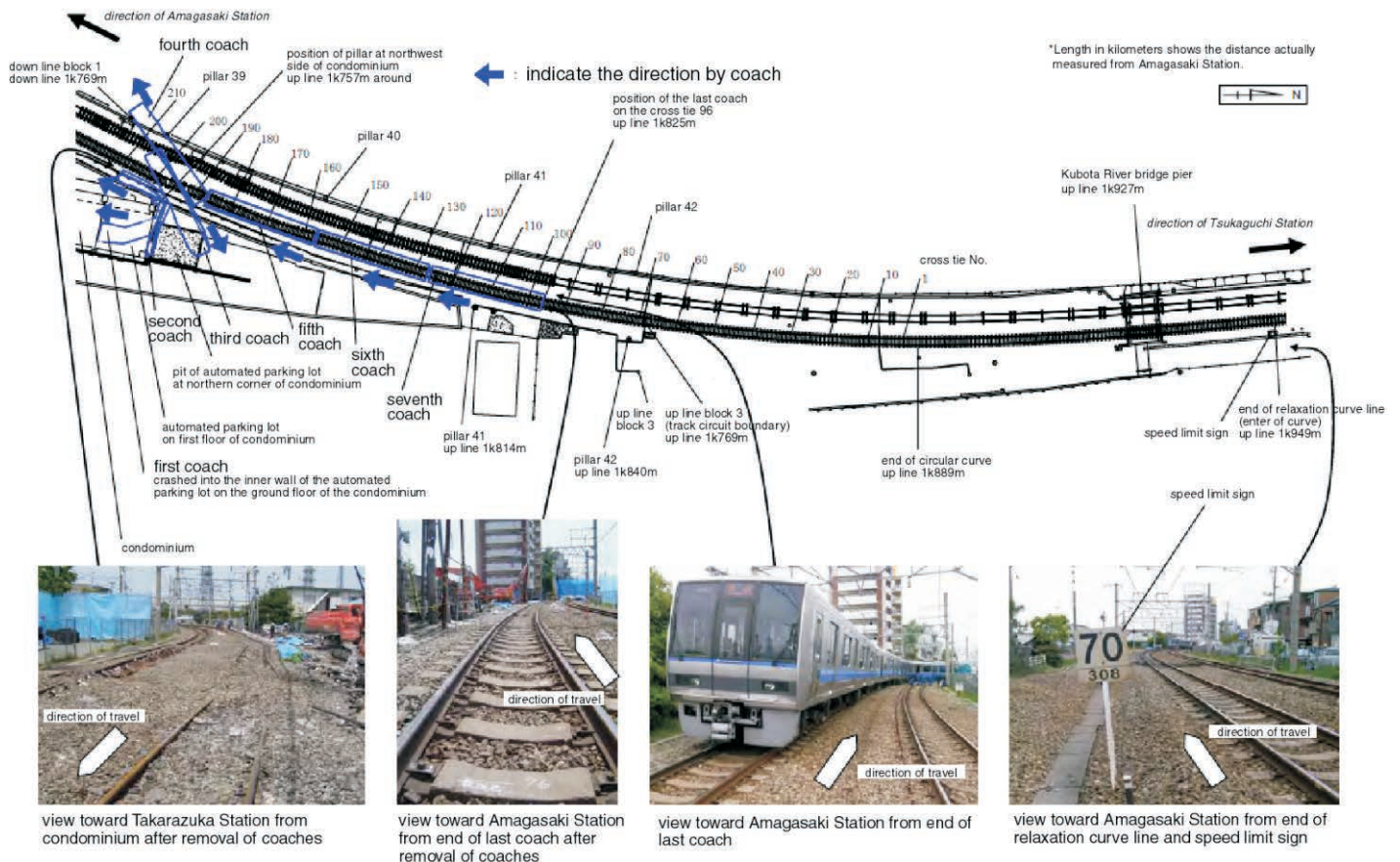


Fig. 3. Sketch map of derailment site.

Table 1. Number of dead and injured. The number of dead includes those who died 24 hours after the accident. The number of injured is tentative as of August 19, 2005, when the West Japan Railways reported to the committee.

	passengers	crew	number
dead	106	1	107
injured	555		555
amount	661	1	662

2.2. General Damage

2.2.1. Railway Facilities

Pillar No.41 at the left side of the track 1814 m from Amagasaki Station was broken off 2.7 m from the top level of the left side of the track.

Damage is shown in **Fig. 4**. White powder was observed on the top level of the left side of the track at 1828 m in the direction toward Amagasaki Station.

2.2.2. Coaches

Major damage to coaches was as follows:

(1) First coach

The front (first) coach was turned over on its side and essentially demolished. A steel bar had pierced the front

of the coach at lower right. The first axle of the front bogie truck were separated from the truck itself and dropped onto the automatic parking lot at the ground floor of the condominium. The first axle of the rear bogie truck was also thrown from the bogie truck and dropped on the right side to the right of the track at 1752 m (**Figs. 5, 6(a)**)

(2) Second coach

The left side of the center of the second coach was crushed against a pillar northwest of the condominium, sandwiching the back of the first coach, and the rear left side was crushed against the northeast pillar of the condominium, catching it there.

The front pantograph was separated off body and fell to the ground between the first and second coaches. The rear pantograph fell near pillar No.41 (**Figs. 5, 6(b)**).

(3) Third coach

The third coach was turned around in reverse against the direction of travel (**Fig. 5**) to block on the down line (direction of Tsukaguchi Station). The front and rear of the fourth coach were damaged and the frame was highly distorted (**Figs. 5, 6(c)**).

(4) Fourth coach

The fourth coach lay beside the Down line track, its

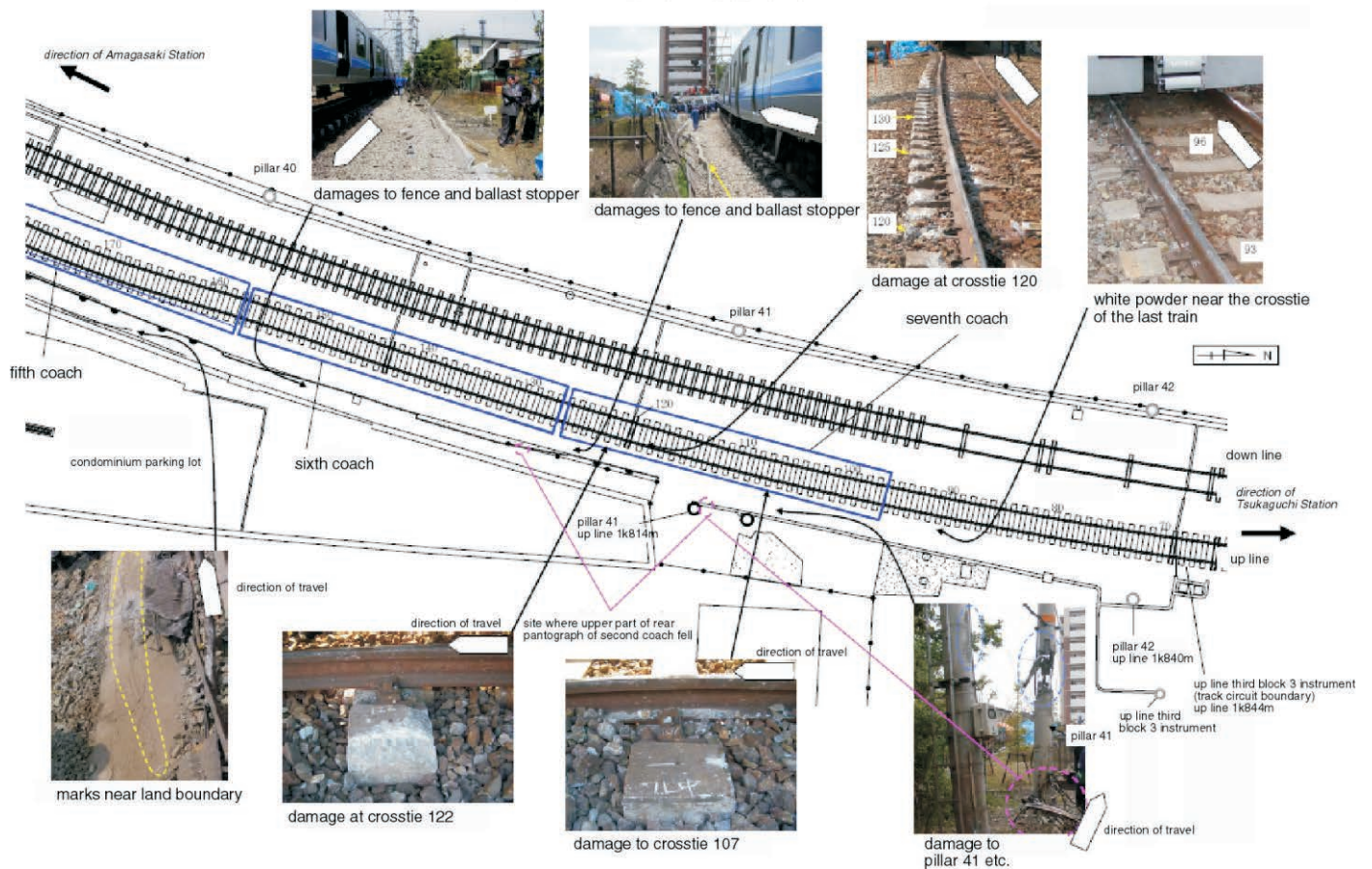


Fig. 4. Damage to railroad facilities.

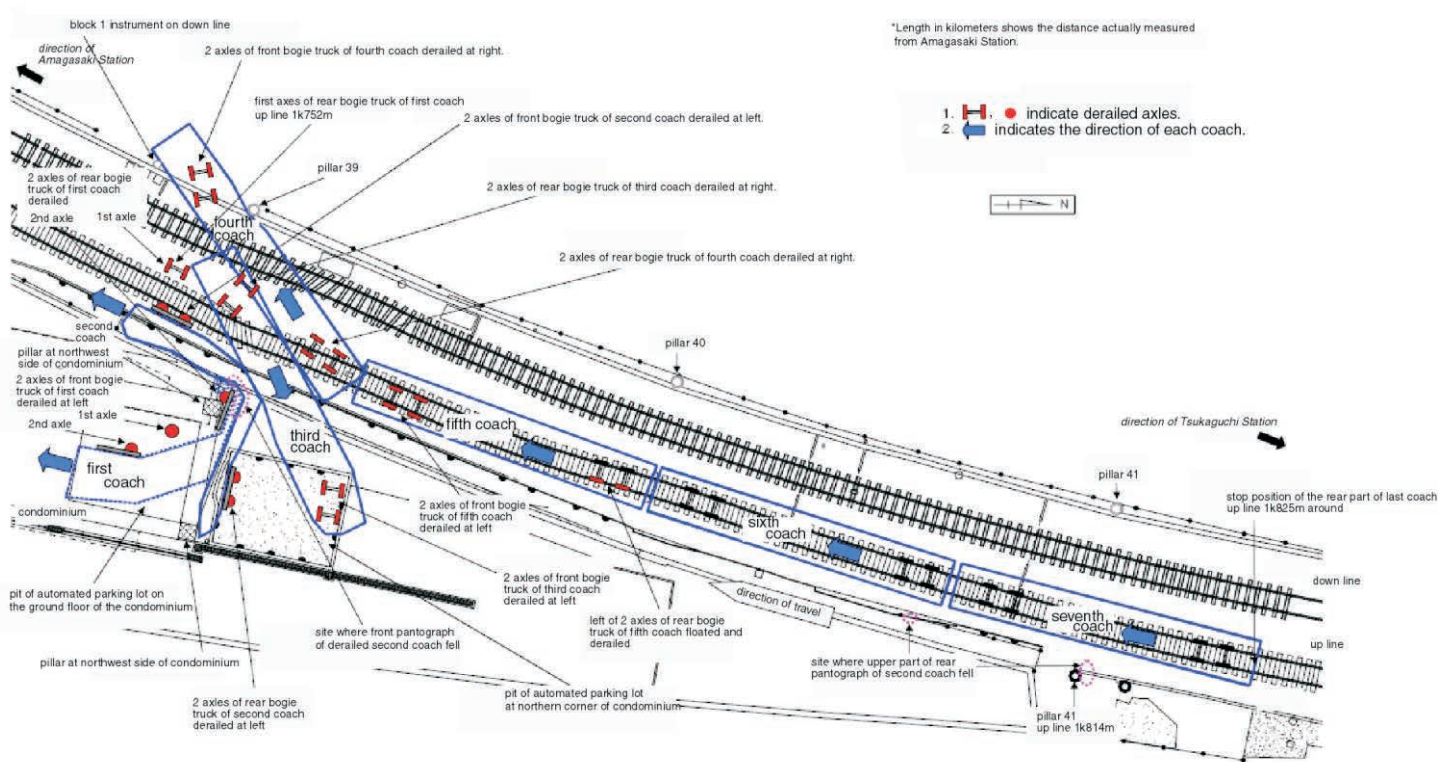
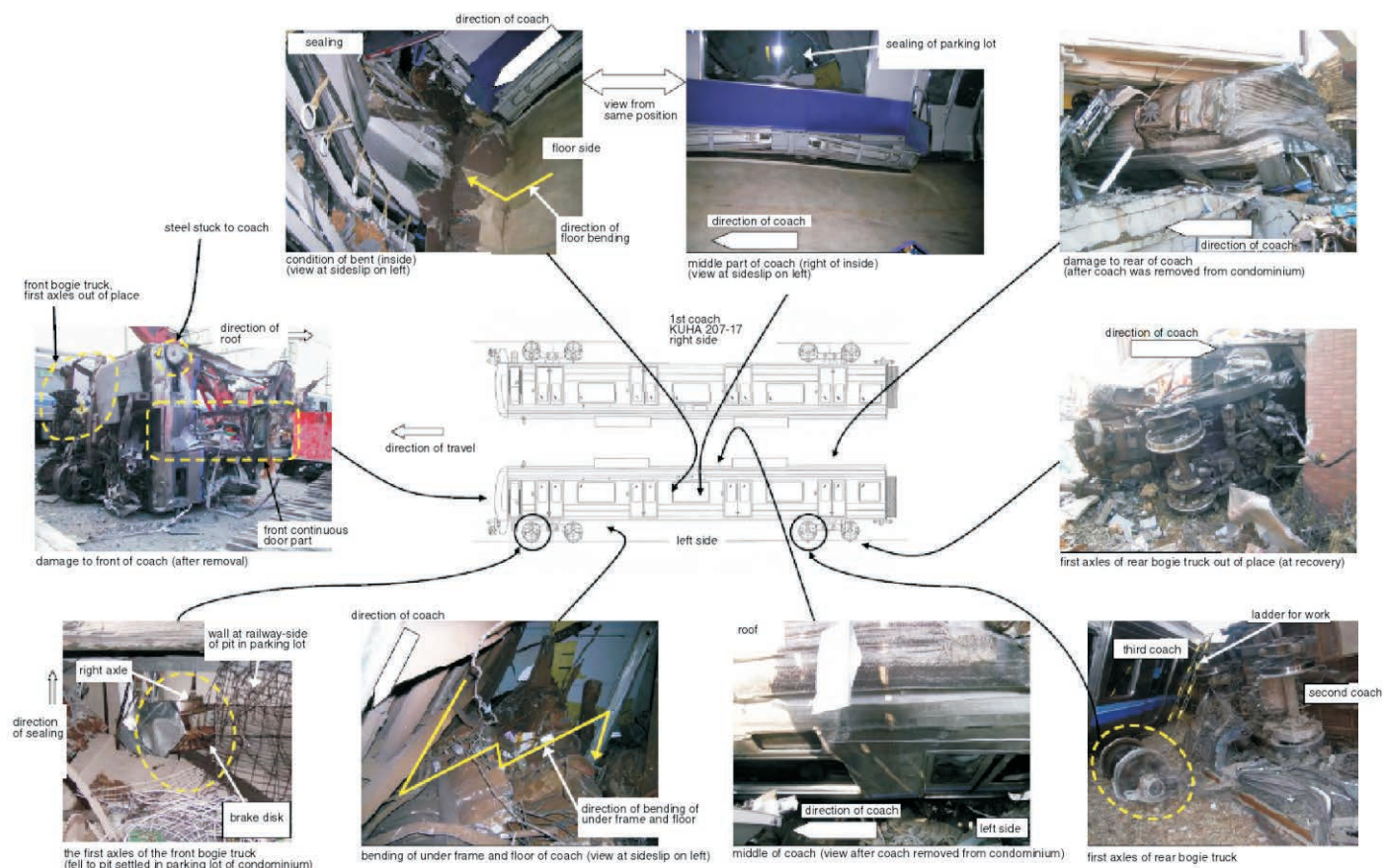
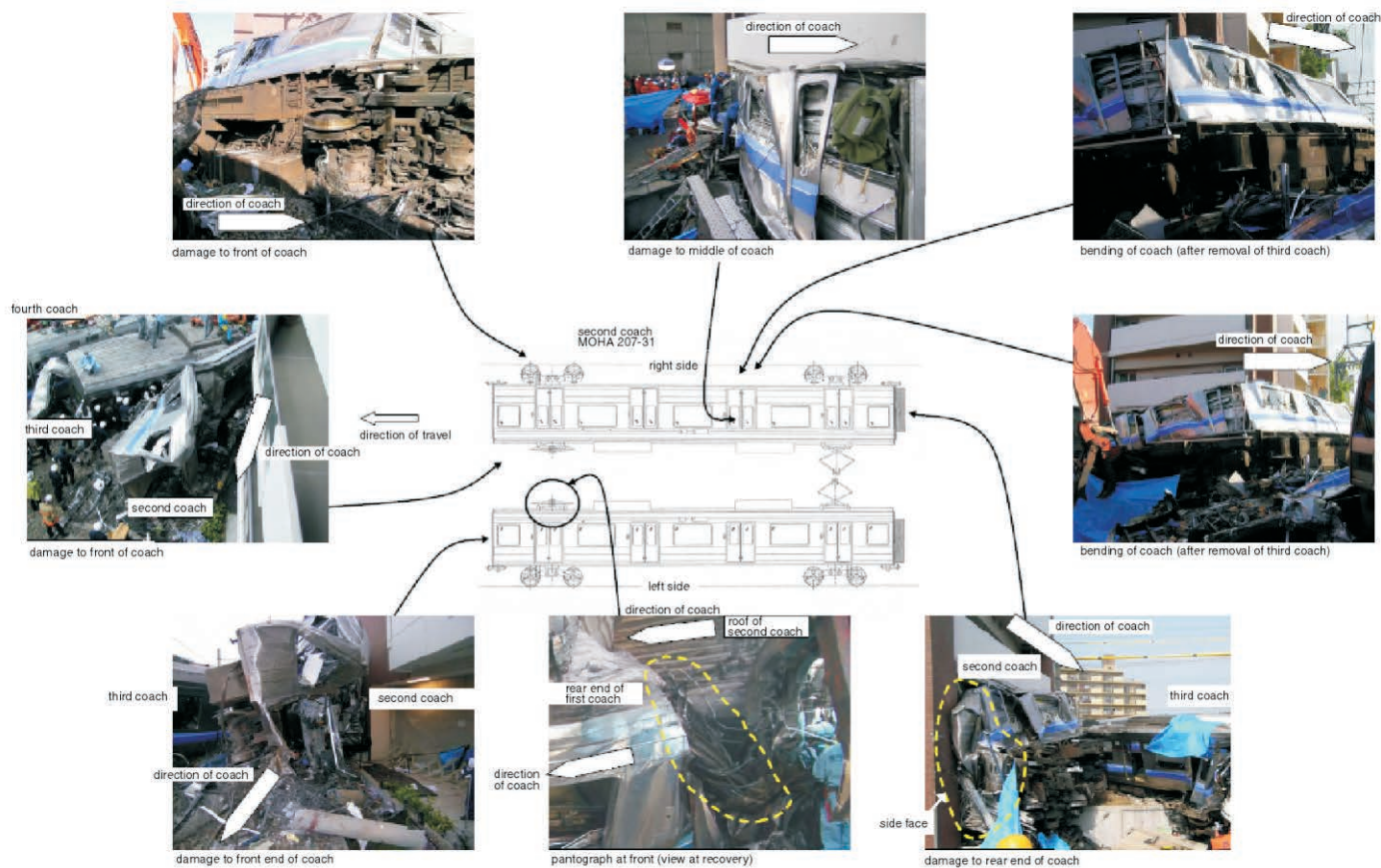


Fig. 5. Derailed coaches.

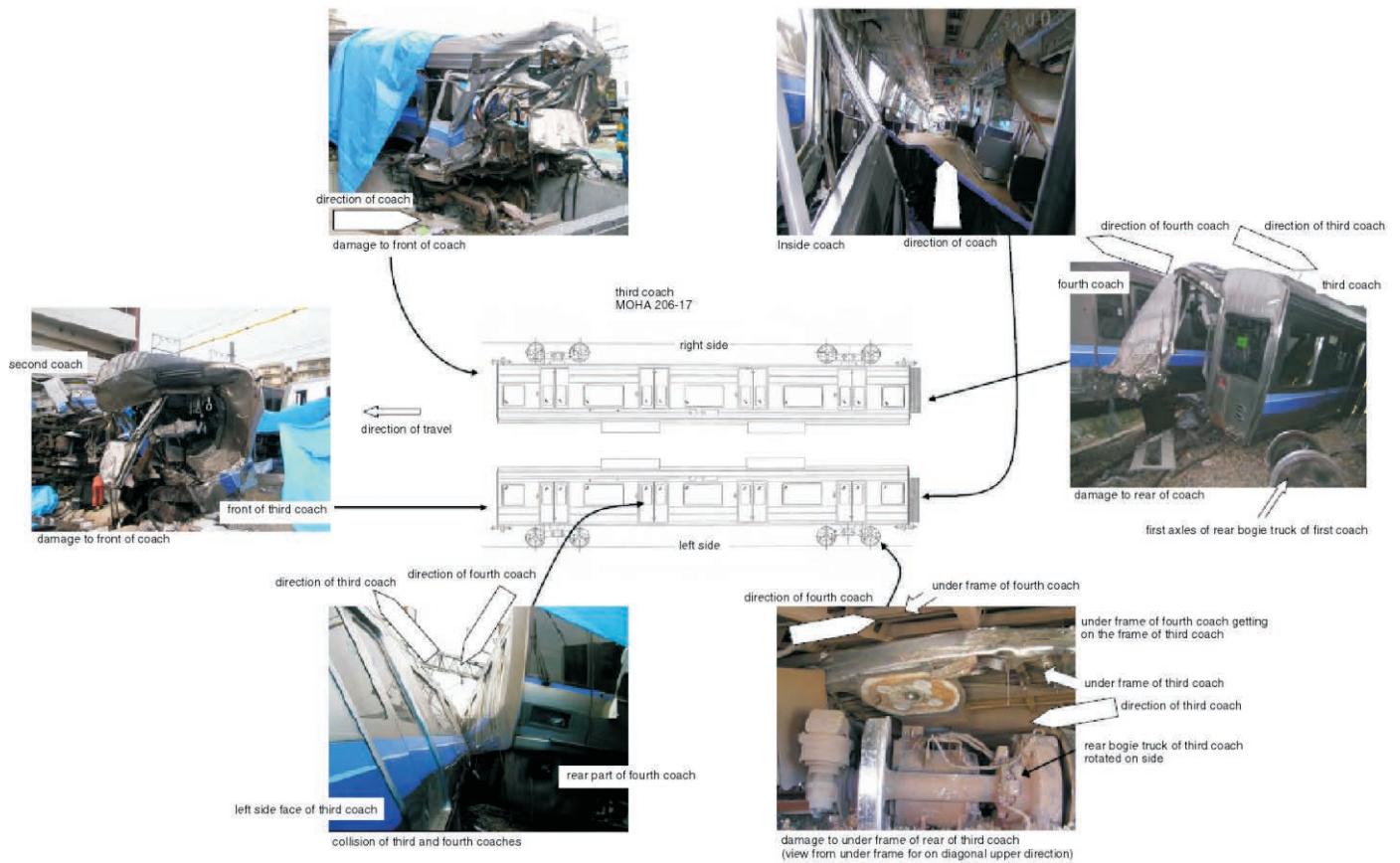


(a) first coach

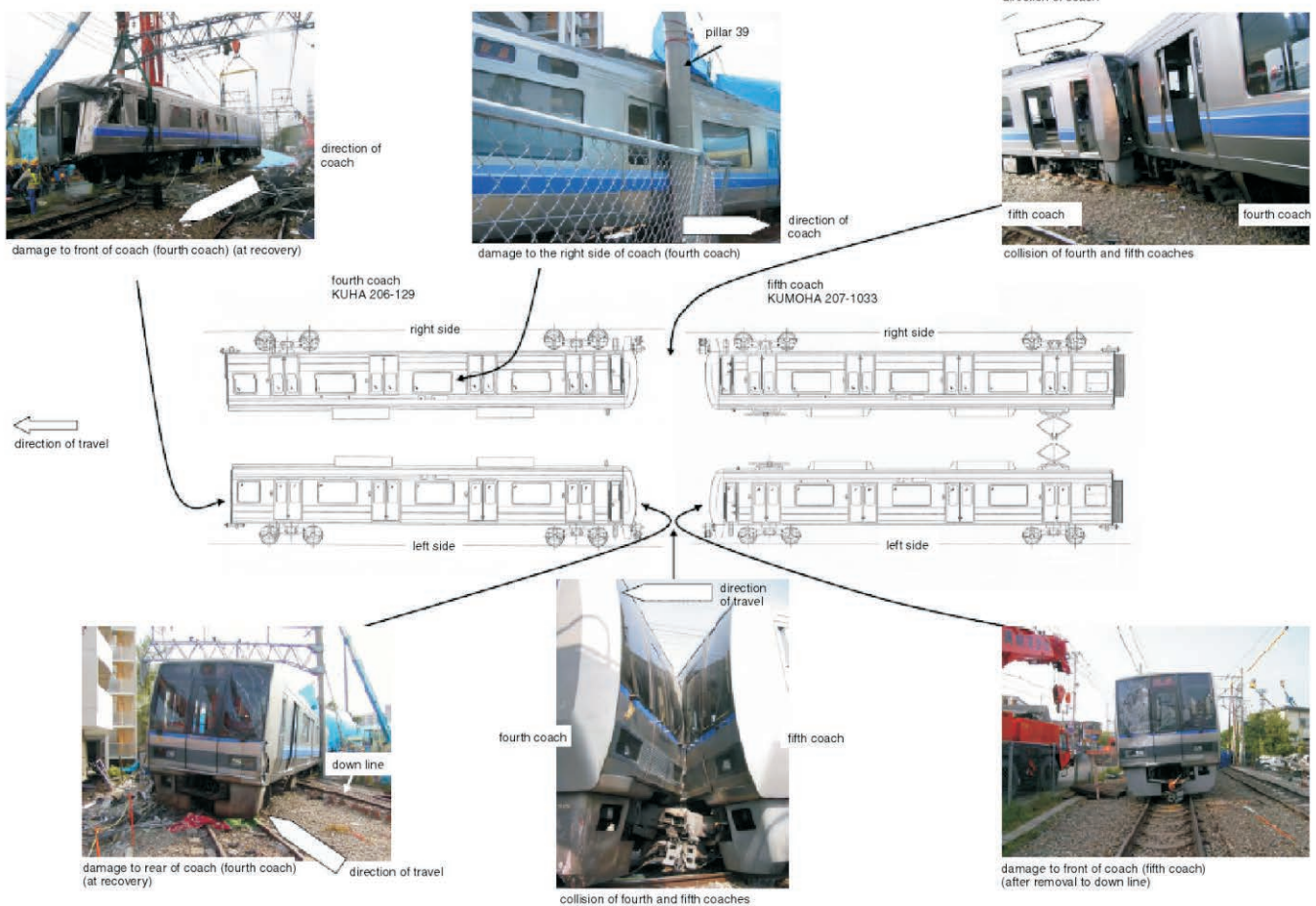


(b) second coach

Fig. 6. Damage to coaches.

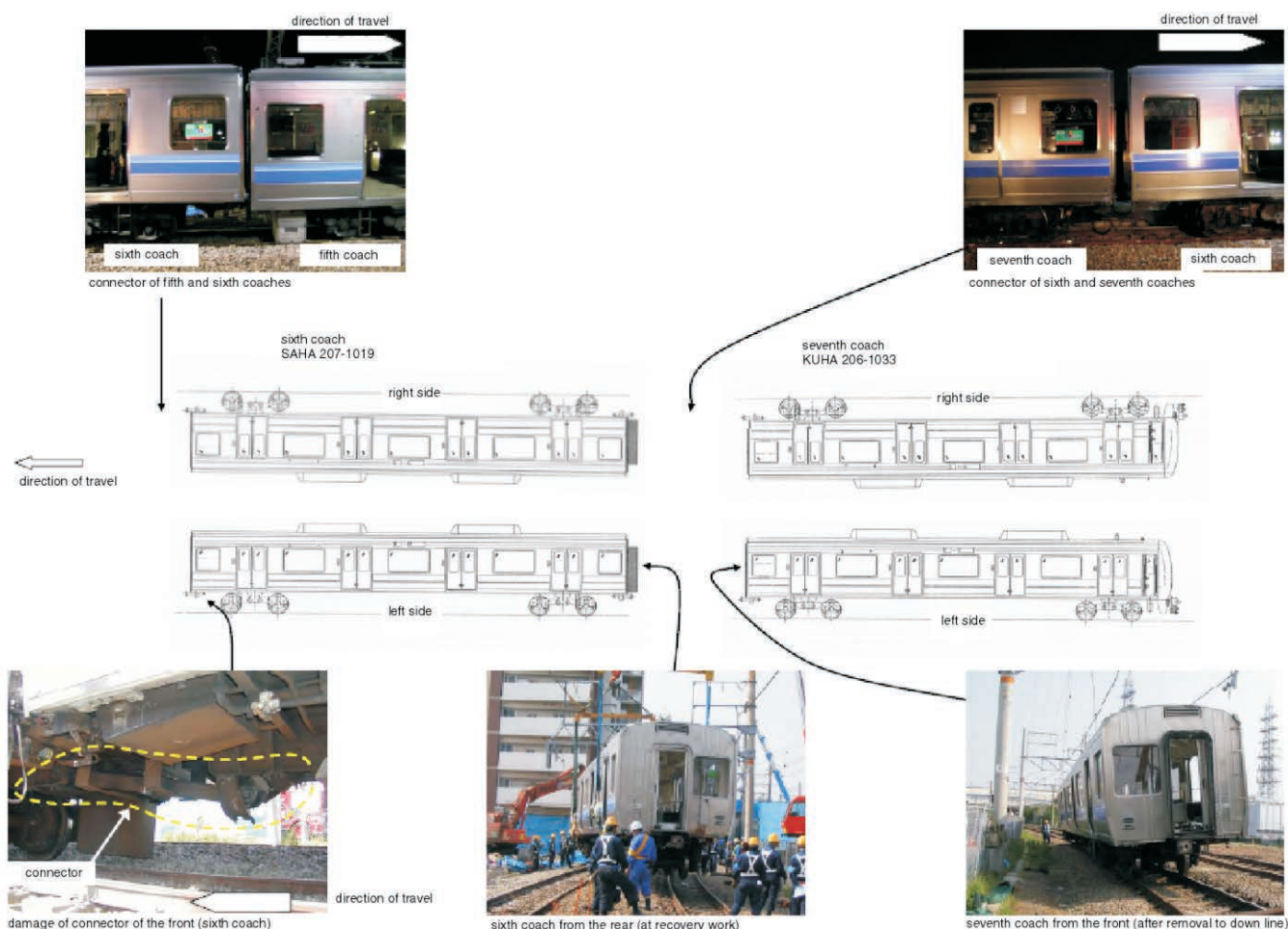


(c) third coach



(d) fourth and fifth coaches

Fig. 6. Damage to coaches.



(e) sixth and seventh coaches

Fig. 6. Damage to coaches.

front damaged and the right side of the center rested against Pillar No.39, which it had damaged (**Figs. 5, 6(d)**).

(5) Fifth coach

The front coupler of the fifth coach was damaged (**Figs. 5, 6(d)**).

(6) Sixth coach

The front coupler of the sixth coach was damaged (**Figs. 5, 6(e)**).

(7) Seventh coach

No specific damage to the seventh coach was observed (**Figs. 5, 6(e)**).

2.2.3. Structures Other than Railway Facilities and Rolling Stock

The condominium was partially damaged and both parking lots at the northern end of the condominium and on the ground floor were partially damaged, as were some of the cars parked there.

3. Information on Train Crew

Driver: 23-year-old man

Went to work for JR West on April 1, 2000.

Acquired an Electric Train Driver's License on May 14, 2004.

No abnormal data observed in physical inspection on February 17, 2005.

According to JR West records, on June 8, 2004, at 09:34, the train the driver was operating overran a station platform by about 100 m. The driver corrected the overrun.

Conductor: 42-year-old man

Went to work for JR West on April 1, 1987. His length of service was 22 years and 1 month (incl. Japan National Railway).

He had worked as a conductor since 1990, 15 years and 9 months.

4. Crew Service and Routes

4.1. Driver's Duties Preceding the Derailment

April 18: 15:57 to 01:25 preceding the next day's service, sleeping at Hanaten dormitory.

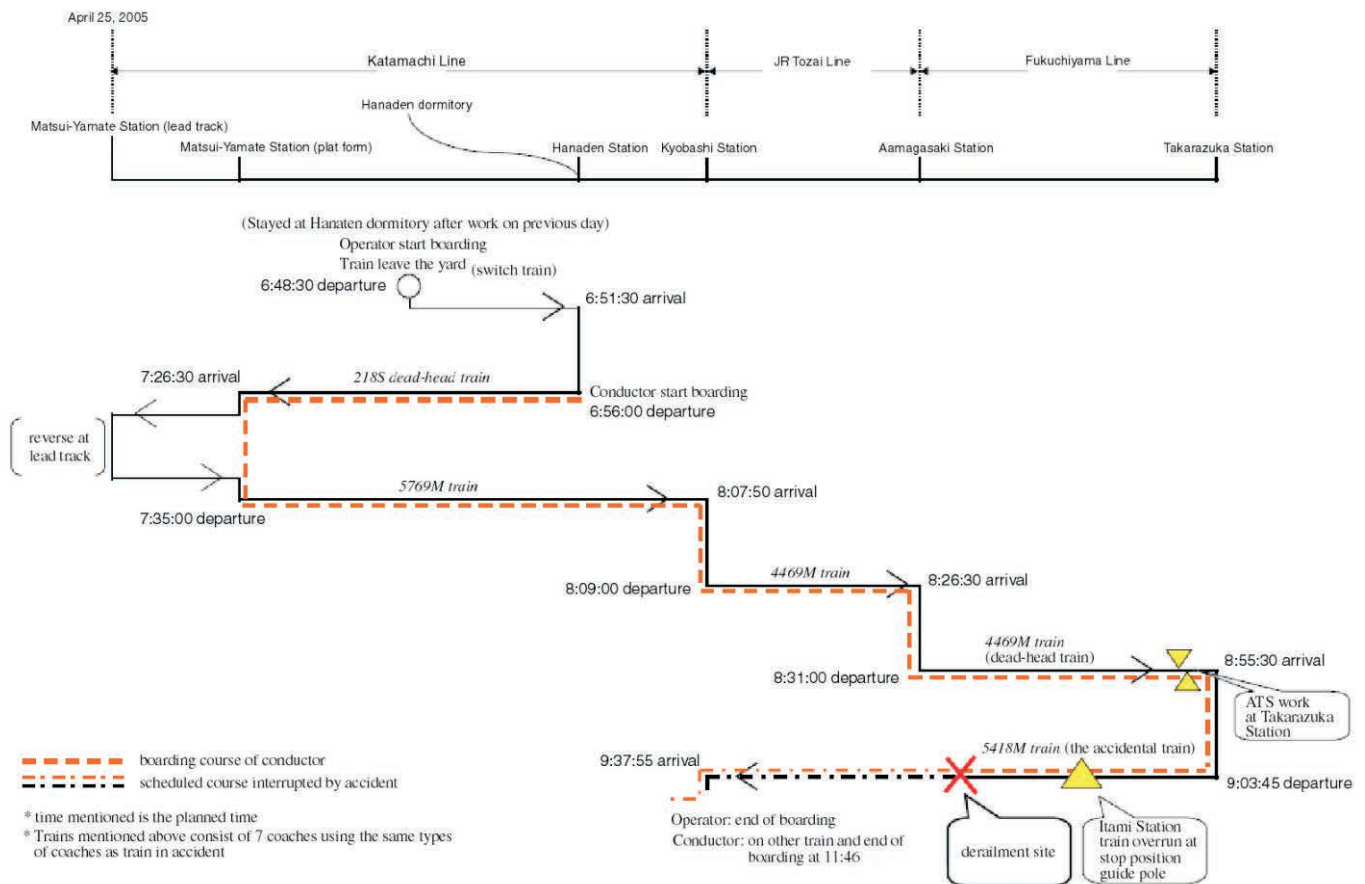


Fig. 7. Driver and Conductor's course of boarding.

April 19: Worked from 06:21 to 09:58 and 18:00 to 19:27 (personal interview).

April 20: Worked from 06:52 to 19:13.

April 21: Scheduled day off.

April 22: Worked from 11:44 to 22:53:9, sleeping at Kyobashi Electric Train Division.

April 23: Worked from 05:25 to 11:06.

April 24: Worked from 13:95 to 23:14, sleeping at Hanaten dormitory.

April 25: Scheduled work from 06:21 to 09:58.

4.2. Driver's Activities on the Day of the Accident

The driver began working at 06:48 with the departure of the train from the garage and was scheduled to finish work at 09:28 with the train's arrival at Kyobashi Station (Fig. 7).

4.3. Conductor's Activities on the Day of the Accident

The conductor begun working with the departure of the train from Hanaten dormitory at 06:56 and was scheduled to leave the train at 09:38 at Kyobashi Station and begin other work at Kyobashi Station. The second job was scheduled to end at 11:46 at Kyobashi Station. The conductor was working in the driver's office in the seventh coach (Fig. 7).

5. Information on Railway Facilities

5.1. Railway Facilities

The up line at the derailment site was a gentle curve from 1949 m to 1880 m and became tighter at 187 m, i.e., up to 1702 m was circular curve with a 304 m curvature.

The Fukuchiyama Line was equipped with Automatic Train Stop (ATS) model ATS-SW from Amagasaki Station to Takarazuka Station, including the accident site. Model ATS-P equipment was scheduled for implementation and ground equipment was being installed. Operations to prevent neglected stop signals, to control excess speed at curves and at turnout and to prevent trains from bypassing designated stations had not yet been implemented. No abnormal points were seen in inspection with operation of high speed track inspection coach at the last inspection by the accident on February 18, 2004 (Fig. 3).

5.2. Inspection of ATS-SW Wayside Coil and Others at Takarazuka Station Precinct

Regarding the ATS-SW wayside coil installed at Takarazuka Station, nothing abnormal was noted at the last inspection or in tests conducted after the derailment,



Fig. 8. Coach model etc.

Table 2. Principal details of coach, etc.

position	first coach	second coach	third coach	fourth coach	fifth coach	sixth coach	seventh coach
identity number	KUHA 207-17	MOHA 207-31	MOHA 206-17	KUHA 206-129	KUMOA 207-1033	SAHA 207-1019	KUHA 206-1033
renewal month	February,1992	February,1992	February,1992	February,1992	March,1995	March,1995	March,1995
empty weight (t)	26.3	35.2	32.2	26.3	37.4	24.8	27.8
Maximum number of persons	150	163	163	150	150	163	150
coach length (m)	20.000						
roof height (m)	3.700						
coach width (m)	2.950						
monitor equipment	old	old	old	old	new	new	new

6. Information on Coaches

6.1. Overview

Model: DC electric coach (1500 VDC)

Number of coaches per train: 7

Model identity number, Principal details: See **Fig. 8**, **Table 2**.

6.2. Brakes, Operation Stick etc.

The main controller in the first coach was equipped with a brake operation stick operated by the right hand and an accelerator operated by the left hand. When the operator pushed the brake handle up to 1 notch from the “off” position, the train operated at its weakest regular braking. When operator pushed it to level 8 to pause at

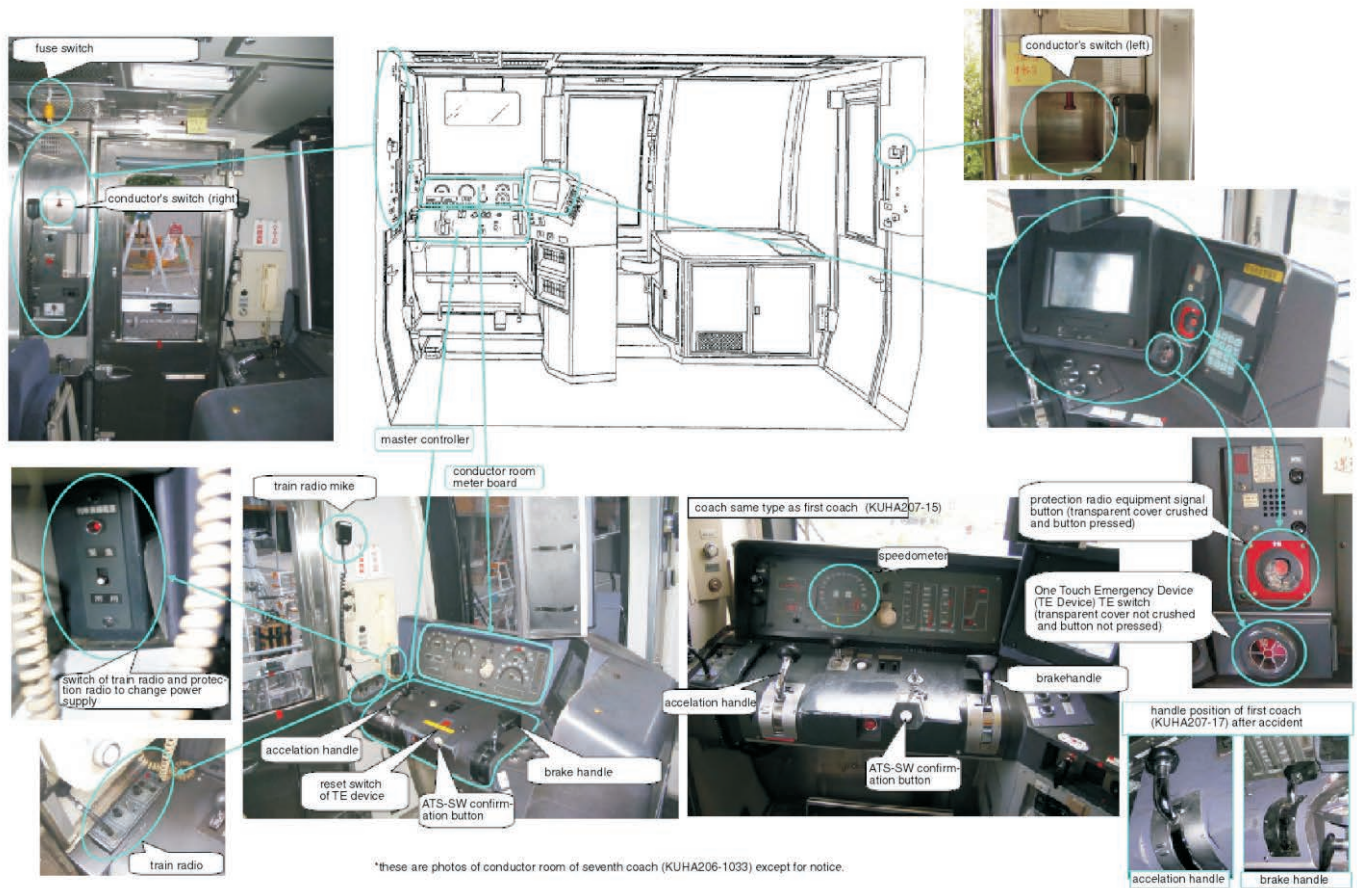


Fig. 9. Equipment arrangement in operation room.

the 8th notch, the train operated at its strongest braking in regular operation. Pushing it another step placed it at the emergency notch, operating emergency braking.

The acceleration handle drove the train at notch 1, which was the weakest acceleration, and notch 6 drove it at the strongest acceleration. According to confirmation just after the derailment, the brake stick was in the Emergency position and the accelerator was off. The brake stick remains in the original position set by the operator even if the operator removes a hand from the brake. If the operator removes a hand from the accelerator, the accelerator is turned off automatically by a spring.

Inspection of the main controller just after the derailment showed nothing abnormal (Fig. 9).

6.3. Speedometer

The speedometer on the operator panel was in the first coach. It was an analog arc graph display with a digital display. The digital display indicated operation up to 150 km/h in 1 km/h increments.

According to materials prepared by the speedometer manufacturer, the speedometer was at the left end of the first axle of the rear truck bogie of the first coach. The meter calculated the train speed by the diameter of the wheel measured in mm. Input to the speedometer was obtained as the diameter in mm divided by 10 (fixed

number).

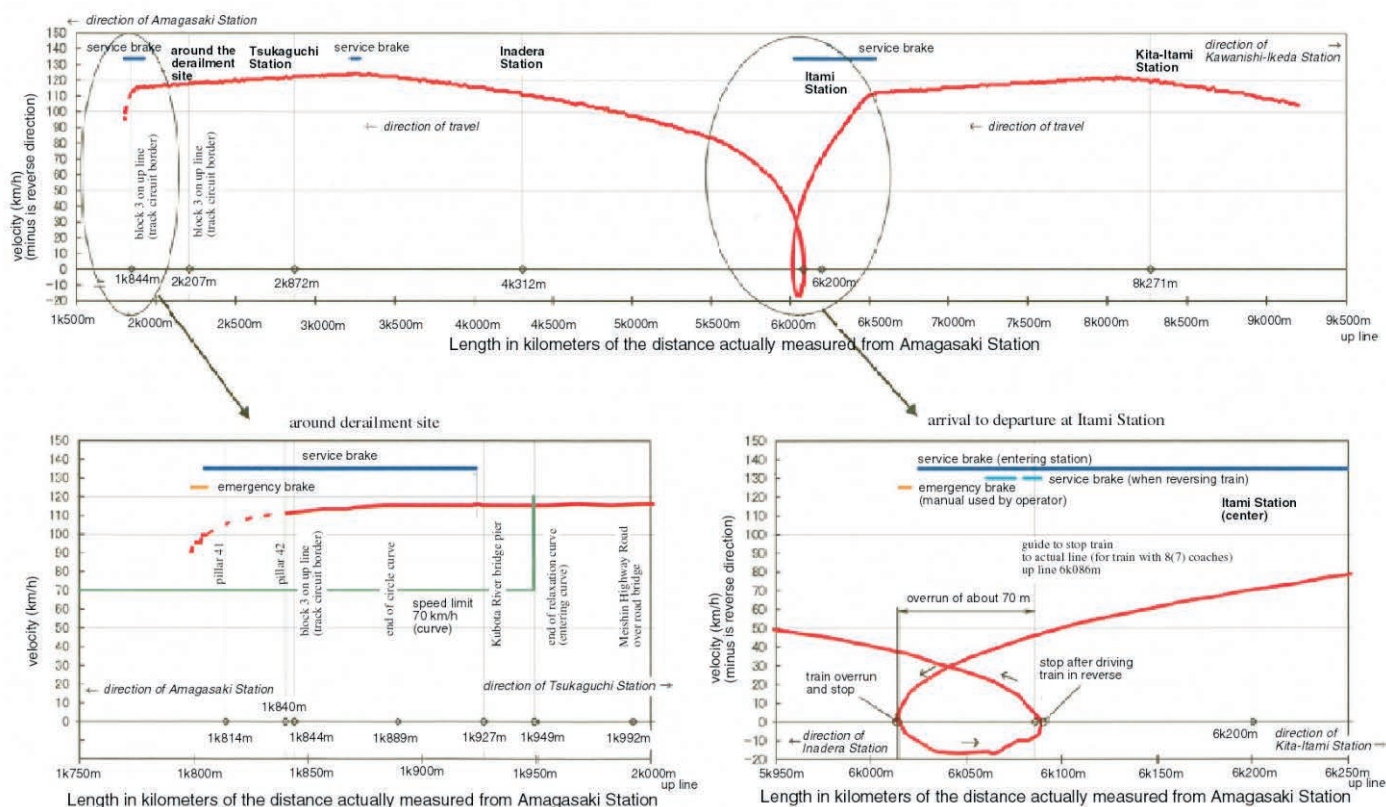
Measuring the error in the case of the same wheel diameter as in the first coach, using the same type of speedometer as in the first coach, the result obtained indicated that if train speed is about 120 km/h, the indication by the speedometer was lower by 2 or 3 km/h than the actual speed.

Based on the above result, calculating in trials the error under the condition of the wheel diameter that would cause the maximum error, using the same speedometer as in the first coach, the speedometer indicates speed lower by about 4 km/h than the actual train speed (Fig. 9).

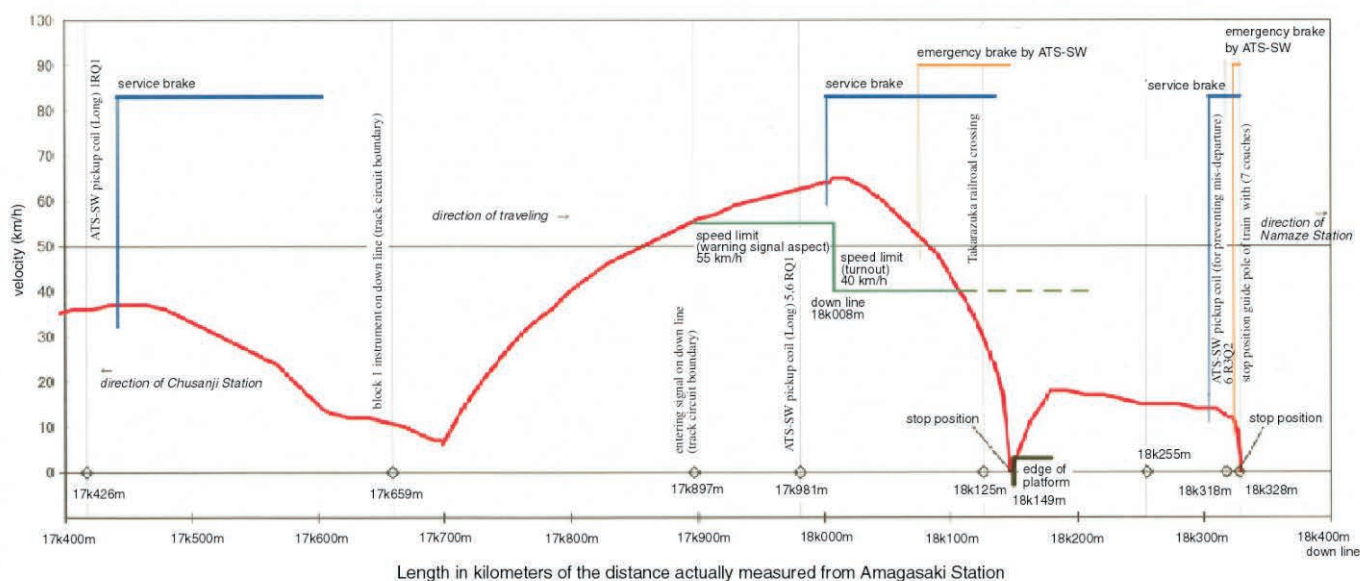
6.4. ATS-P Board Equipment Recorder and Records

As mentioned in Section 5.1, in the railroad section between Amagasaki Station and Takarazuka Station on the Fukuchiyama Line including the accident site, none of the functions for preventing violations of stop signals, exceeding curve speed limits, exceeding turnout speed limits, or bypassing station had been implemented. The train in this case extended its service to the JR Tozai Line, where an ATS-P wayside coil and ATS-P were operating, so it also had ATS-P pickup coil.

ATS-P pickup coil the first coach recorded information on train location, speed, braking, and real



(a) Kita-Itami Station to accident site. This estimate is the ATS-P record from the first coach conducting approximate correction of wheel diameter and process time of location detection signal of ATS-P wayside coil.



(b) dead-head train arriving at Takarazuka Station. Unlike in (a), this estimate is not compensated for.

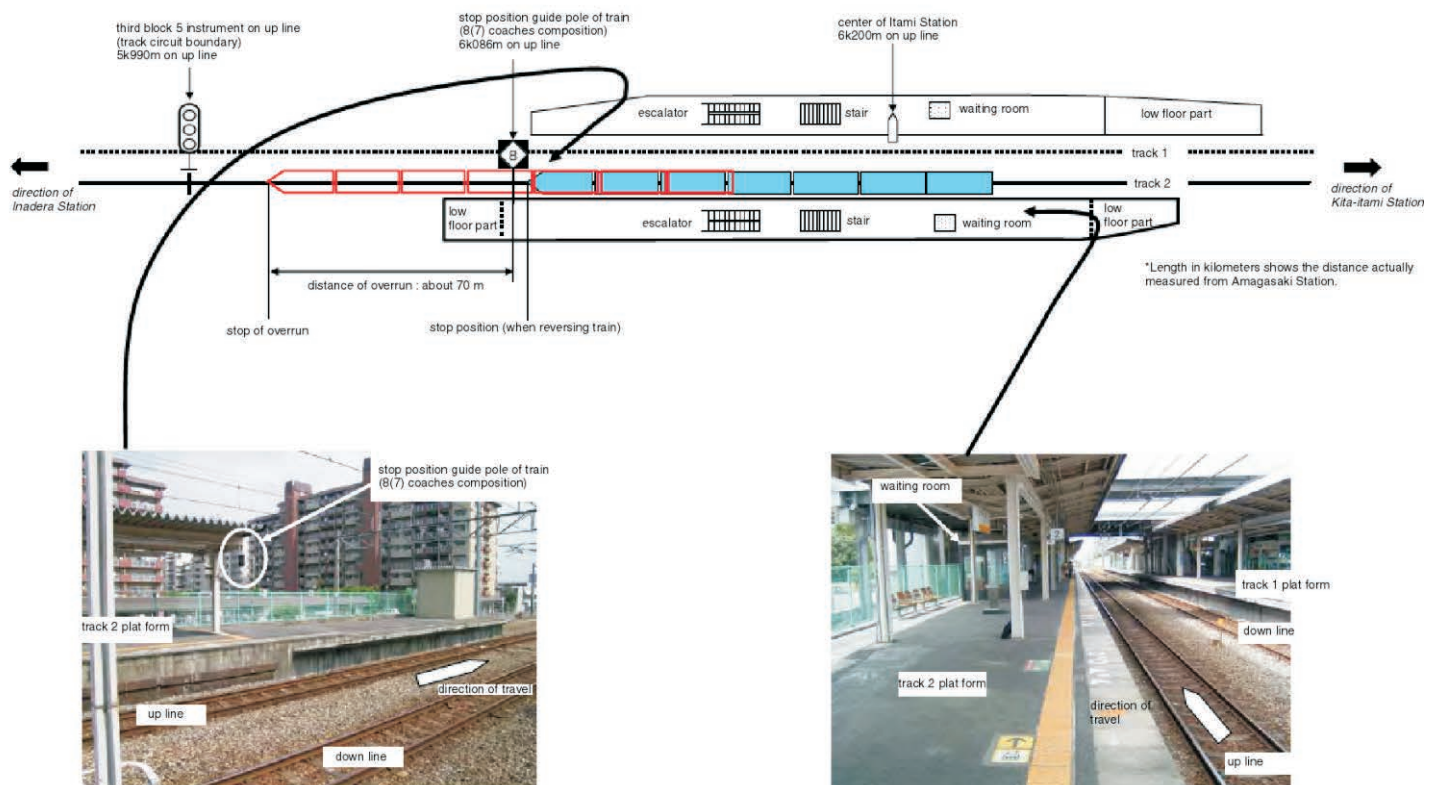
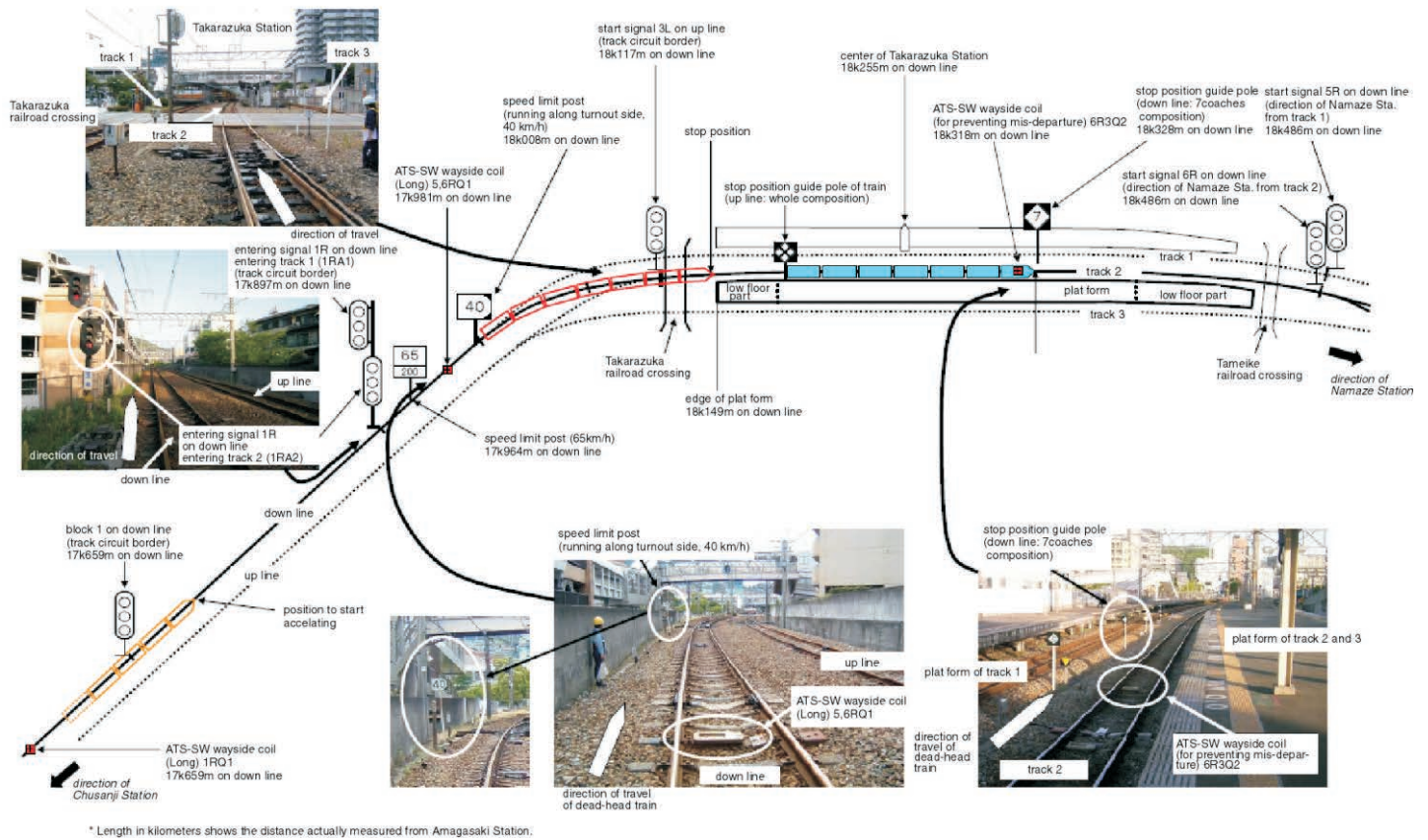
Fig. 10. Records recorded by ATS type equipment (rough estimate).

time, triggered by emergency braking through hand controls, etc., if the first coach were operating. The ATS pickup coil recorder in the first coach left records generated at Itami Station arrival triggered by the functioning of the brake and operation of the emergency brake and records including information on emergency braking triggered by a signal generated when ATS-P

equipment was damaged near the derailment site.

ATS-P pickup coil in the seventh coach had record information similar to that in the first coach and triggered by the emergency brake when the train was operated from the seventh coach. ATS-P pickup coil left records related to two emergency brake applications.

Figure 10 graphs records from pickup coil in the first



and seventh coaches relating locations (point) of the first coach and train velocity and the state of the emergency brake. In the records for the train in this case, i.e., record by ATS-P pickup coil on the first coach, approximate correction of wheel diameter, and approximate correction in process time on the location of detection signals of the ATS-P wayside coil were made. In the records of ATS-P pickup coil the seventh coach, however, no correction was made.

Figure 10 indicates that the train overran the platform by 70 m and backed up at Itami Station. It also indicates that a regular braking signal was issued when the train entered the right curve 304 m in radius beginning from the up line (direction of Tsukaguchi Station) 1949 m traveling at over 110 km/h. ATS-SW emergency braking directives were issued twice when the train arrived at Takarazuka Station.

Concretely, **Fig. 10** shows the situation; (1) the dead-head train passed the ATS-SW wayside coil (long) 5,6 RQ1 of starting signal on the down line, (2) service brake worked, (3) entered the section with a speed limit of 40 km/h to 60 km/h, (4) ATS-SW emergency brake worked the first time and, (5) stopped at the edge of the platform at Takarazuka Station traveling in the direction of Amagasaki Station.

The dead-head train then restarted and the service brake was used again, and when the train passed the ATS-SW wayside coil for preventing mistaken departures 6R3Q2 starting signal on the down line, ATS-SW emergency brake operated the second time, then the train stopped at stop guide pole (**Figs. 11, 12**).

6.5. ATS-SW Pickup Coil and Records

ATS-SW pickup coil was being installed in the first, fourth, fifth, and seventh coaches for trains. Pickup coil in the first coach was in service for the train before the derailment and that installed in the seventh coach was in service for dead-head trains. Each have left records.

No record of emergency braking by ATS-SW pickup coil was found in the ATS-SW pickup coil recorder.

ATS-SW transmitter/receiver equipment installed in the seventh coach had records of two ATS-SW emergency braking operations at arrival of the dead-head trains at Takarazuka Station.

The first record related to ATS-SW wayside coil was 5, 6RQ1 for the down line (direction of Amagasaki Station) departure signal. According to the record, no emergency braking by ATS-SW transmitter/receiver equipment or confirmation was made in receiving of stop signal aspect information.

The time required from reception of a stop signal to operation of the emergency brake by ATS-SW was 4.2 seconds.

Inputting information on stop signals aspect on trial and measuring time, results met the standard of the train company, which ranges from 5 to 6 seconds. On this issue, the handbook for operating explanations of ATS-SW receivers and transmitters refers recording as

time administration incorrect.

The second record related to ATS-SW wayside coil for preventing mistaken departures for departure was the signal instrument (6R3Q2) for down line (direction of Tsukaguchi Sta.) trains. The record shows that receiving absolute stop information and emergency braking by ATS worked immediately. Records also indicated confirmation just after the receiving of the absolute stop signal aspect. According to reports by JR West, cases in which a train was stopped by ATS-SW wayside coil emergency braking numbered 46.

6.6. Monitor Equipment and Records

The train involved in the derailment had monitor equipment differing from the ATS-P pickup coil recorder described in section 6.4 or the ATS-SW pickup coil recorder.

The monitor in the fifth to seventh coaches records velocity and distance of train travel triggered by emergency braking during train operation regardless of whether operation is in the fifth and seventh coaches.

6.7. EB Equipment

The first and fourth coach did not have EB equipment, but the fifth and seventh coaches did.

7. Information Regarding Operation of the Train

7.1. Speed Control for Dead-Head Trains Arriving at Takarazuka Station Platform No.2

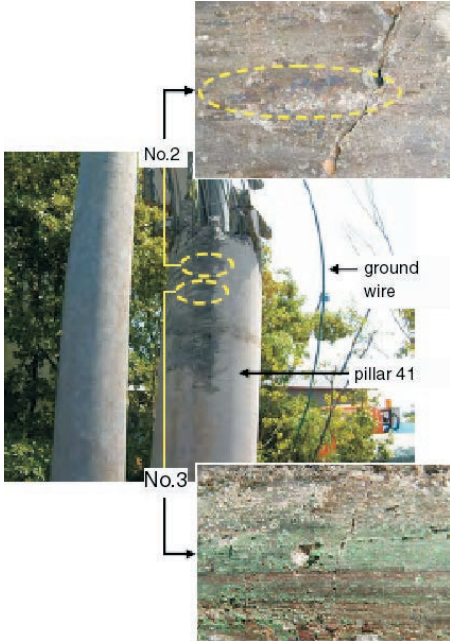
Dead-head trains are permitted to run at up to 120 km/h when there is no specific speed control. When a train enters platform No.2 at Takarazuka Station, speed is set at a maximum of 55 km/h for the section from entering signal (1RA2) at down line 17k897m point and from the down line 18k008m point a maximum of 40km/h indicated by speed limit signals indicating the speed limit for trains running along a turnout side from a turnout.

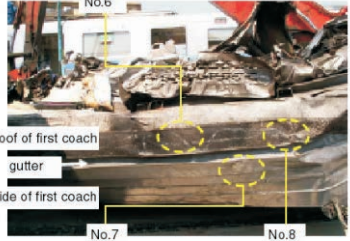
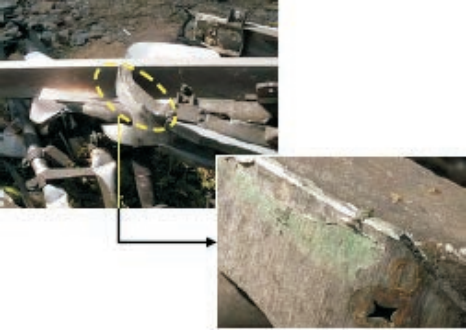
On entering the first track, however, in the case that the down line entry signal (1RA1) indicated a caution signal, speed would be limited to 55 km/h or less from this signal on. If the signal indicated a proceed signal, there would be no speed limit in terms of this signal, but the speed is limited to 65 km/h or less based on the speed limit sign farther from the beginning of the right curve, that is, or 17k964m on the down line (**Fig. 11**).

7.2. Speed Control and Other Information from Departure from Itami Station to Derailment Site

The train in this case may operate at up to 120 km/h on the railroad section from Itami Station to the transition curve terminus (curve entrance), that is, 1k949m on the up line, because there is no speed limit on

Table 3. Results of constituent analysis of miscellaneous material at railway facilities and coaches.

No.	sample	gathered at	appearance	analysis overview	anticipated material	anticipated matter	situation on gathering
1	rail white powder	head of up line rail, left, between rail road ties 88 and 89	white powder	SiO ₂ Fe ₂ O ₃ Al ₂ O ₃ Na ₂ O K ₂ O CaO quartz feldspar mica clay minerals	granite	ballast	
2	scratches on pillar	pillar 41 (1k814m on up line)	miscellaneous scratches (metallic luster)	Fe Cr Si Ca Al Ni	stainless steel	coach	
3	miscellaneous matter on pillar	pillar 41 (1k814 on up line)	green sticky miscellaneous matter (gathered in particles)	same spectrum of the cover vinyl of ground wire of pillar 41	—	vinyl cover of ground wire of pillar 41	
4	miscellaneous matter on pillar	pillar at rail road tie 108	miscellaneous matter on pillar	same spectrum of coach roof cloth	—	coach roof cloth	

No.	sample	gathered at	appearance	analysis overview	anticipated material	anticipated matter	situation on gathering
5	miscellaneous matter on fence	side of railroad tie 156 fence	lustrous miscellaneous black to brown matter (collop like)	Fe O Cr Si Al Ni Ca C	stainless steel	coach body	
6	miscellaneous matter on first coach	roof of the first coach	miscellaneous green matter	same spectrum of the cover vinyl of ground wire of pillar 41	—	vinyl cover of ground wire of pillar 41	
7	miscellaneous matter on first coach	side face of the first coach	miscellaneous green matter	same spectrum of the cover vinyl of ground wire of pillar 41	—	vinyl cover of ground wire of pillar 41	
8	miscellaneous matter on first coach	roof of the first coach	powder miscellaneous gray matter	same spectrum of mixture of polyvinyl tube for ground wire cover of pillar 41 and dirt of roof	—	polyvinyl tube for ground wire cover of pillar 41	
9	miscellaneous pantograph matter	rear pantograph of second coach fallen by pillar 41	miscellaneous green matter (sheet like)	same spectrum of the cover vinyl of ground wire of pillar 41	—	vinyl cover of ground wire of pillar 41	
10	miscellaneous skirt matter	left depression in skirt of first coach	miscellaneous white matter	Ca(OH) ₂ CaCO ₃ quartz feldspar mica	cement, aggregate	concrete	

this section. In the right curve from 1k949m to 1k642 m on the up line, including the accident site, speed is limited to 70 km/h or less based on the speed limit sign (Fig. 3).

8. Information on Train safety

8.1. Train Radio and Safety Radio and Their Operation

The cabs of the first, fourth, fifth, and seventh coaches have train radio for communication between the



Fig. 14. Dead-head train, Limited Express No.3013M (Kita-Kinki No.3) traveling toward the derailment on the opposite track after the derailment (by courtesy of the Amagasaki Municipal Fire Department).

operation center and train operator or conductor and safety radio.

For the train radio, the operation center uses two-way operation enabling receiving and transmitting communication at the same time. Cabs of the first, fourth, fifth, and seventh coaches use semi-two-way communication that does not enable reception and transmission at the same time.

Train radio and safety radio in the same cab have the same power source as the regular one. According to the train company's report, in case a regular power source could not be used, the company has provided new coaches manufactured after January 1994 among coaches running on ordinary lines (coaches limited to those with cabs; this type of coach is called "the coach in question" below) with a reserve power source for the train radio and safety radio, with a few exceptions. The train company has begun to provide coaches in question manufactured before December 1993 with reserve power sources since November 1995. On the day of the accident, 74% of all coaches, including the first, fourth, fifth, and seventh coaches of the train in this case, have reserve power source.

In addition, some coaches are provided with reserve power source (about 12% of all coaches including the fifth and seventh coaches of the train in this case), without changing the power source switch from "regular" to "emergency," it is set so that neither train radio nor safety radio would be provided with power from a reserve power source. The rest of the coaches are provided with reserve power sources (about 62% of all coaches in question, including the first and fourth coaches of the train in this case), without changing the power source switch to "emergency." The train radio would not be provided with power from reserve power sources, but the safety radio would be provided with power from the reserve power source.

According to confirmation after the accident,

although the transparent cover for preventing mistaken operation was broken and behind the cover the transmission button for the safety radio in the seventh coach was pressed, the power source switch in the seventh coach remained at "regular," meaning that the safety radio did not function immediately after the accident. The train radio in the seventh coach could not be used, either.

In the first coach, the transparent cover for preventing mistaken operation was not broken and the transmission button for the safety radio behind the cover was not pressed (**Figs. 8, Table 2**).

8.2. One-Touch Emergency Operation (TE) and Functions

The seventh coach had TE. The TE is used in emergencies requiring emergency stoppage of a train. When the TE switch is pressed, an emergency brake operates and the safety radio issues defense signals while sounding the whistle and lowering the pantographs.

The transparent cover on the TE switch preventing erroneous operation had not been broken in the seventh coach and the button had not been pressed.

TE system was not installed at first coach (**Fig. 10**).

8.3. Train Safety Equipment Such as Fuse etc. and its Use

Although the seventh coach had a fuse, it was not used, nor were the portable fuse or rail circuit breaker.

8.4. Train Radio and Safety Radio Use

JR West regulates crew operations based on in-house rules covering abnormal and emergency events – "Train Crew Work Standard (local line) For Emergencies" and "Work Standard For Crews Of Motive Power Vehicle (local line) – For Emergencies." These rules instruct drivers or conductors to use implement reserve power by turning the power source switch from ordinary to emergency for the train radio.

They did not have similar rules for the train safety radio, however.

8.5. Stoppage of Trains on Opposite Tracks

Just after the derailment, down line Limited Express No.3013M (Kita-Kinki No.3) was traveling toward the derailment on the opposite track, but the driver received no signals from the derailed train.

After the operator had recognized the caution signal on the down line, the second block signal 1k350m on the down line, the operator responded in confirmation to the stop signal of the ATS-SW wayside coil (long) 1Q of down line the first block signal 1k769 m on the down line, and recognized the flash signal of the special signal at the first Shin-Yokomakura railroad crossing located southwest of the condominium. The operator stopped Kita-Kinki No.3 over 100 m ahead of the first block signal.

9. Component Analysis Results of Information Collected from Railroad Facilities, Coaches, etc.

Component analysis results of information collected from railroad facilities, coaches, etc., are shown in **Table 3**.

10. Information on Weather

The Toyonaka Regional Weather Observatory is located 5 km north of the accident site and the Osaka District Meteorological Observatory 11 km southeast of it.

Records on the weather at 09:00 on the day of the derailment showed that the temperature was 19.3 degrees with an east wind of 4 m/s at the Toyonaka Observatory and 19.3 degrees with a north northeasterly wind of 2.6 m/s at the Osaka District Observatory. No rainfall was recorded for 4 days, including the day before the derailment, and no humanly detectable earthquake was recorded according to Japan's Meteorological Agency.

reference:

- [1] "Report of Fukuchiyama Line Derailment Accident of West Japan Railways (report on progress)," Aircraft and Railway Accidents Investigation Commission, September 6, 2005.