Opinions on the improvement of safety of the freight train operation

The three derailment accidents by the freight train, which occurred from April, 2012, to June, 2014 at Esashi Line, have the common situation such as that the outer rail side wheels of the freight wagon in the freight train running in relatively sharp curve near the limited speed, derailed by flange climbing.
As the probable causes for each accident were described in each investigation report, it was probable that these accidents were caused by complex combination of the factors, such as vehicle, track, loading of the freight etc., although their effected levels were different.
In addition, the Japan Transport Safety Board analyzed the issues to be dealt with cooperation by the parties concerned towards the improvement of the safety and the prevention of the derailment accidents of the freight train due to the complex combination of the factors such as vehicle, track, freight loading, etc., based on the knowledge obtained from the previous investigations, integrating the investigated results of these three derailment accidents of the freight train occurred in Esashi Line. (Refer to the attachment.)
The railway system is the integration of the various technology area, such as civil engineering, vehicle technology, electric engineering, operation, etc. Hence, the interested parties of the freight railway transportation, such as the passenger railway operators charged with track maintenance, the freight railway operators charged with vehicle management and operation etc., the freight transporters and the freight senders charged with loading freight and the railway vehicle makers manufacturing the freight wagons, are related with each other.
So that, in view of the results of these accident investigations, the Japan Transport Safety Board expresses its opinion as follows to the Minister of Land, Infrastructures, Transport and Tourism, pursuant to Article 28 of the Act for Establishment of the Japan Transport Safety Board in order to promote the parties concerned to consider the issues analyzed by the Board to improve safety for the freight train operation.
Here, when some measures were implemented according to the following opinions, please notify the Board.

1. Let the context of the accident investigation reports about the three derailment accidents of freight train occurred in Esashi Line and the attached Opinion, well known widely, to the railway operators provided tracks to freight train operation, freight railway operators, freight transporters using freight trains, railway vehicle manufacturers, etc.

2. To supervise and guide the railway operators based on the laws and ordinances, to implement smoothly the required measures for prevention of recurrence described in each accident investigation report.

3. To promote the persons concerned in railway operators, railway vehicle manufacturers, freight transporters using freight trains, freight senders, research and development organization, etc., to

investigate in cooperated with each other, about the issues related with vehicles such as design of freight wagon, issues related with track such as track category and track technology in each section, issues related with freight such as loading methods, etc., towards the improvement of safety for the freight train operation.

Attachment

On the improvement of running safety of the freight train
(Tentative translation)

Summary

Three derailment accidents of the freight train occurred in Esashi Line, from April, 2012, to June, 2014. It is probable that these accidents were caused by complex combination of the factors, such as vehicle, track, loaded freight, etc.

To prevent recurrence of the same sort of the accidents and to improve running safety of freight train further, it is required for the parties concerned in railway operators providing their tracks for freight train operation, freight train operators, freight transporters using freight trains, freight senders, railway vehicle manufacturers, research and development organizations, etc., in cooperated with each other, to grapple with issues related with vehicles such as design methods of suspension device for freight wagons, issues related with tracks such as maintenance methods for track irregularity, and issues related with loading freights such as the loading methods considering prevention of unbalanced loading and height of the gravity center of freights etc., based on the analyzed results during investigation of the derailment accidents in Esashi Line, and obtain appropriate margins against derailment as a whole. The Ministry of Land, Infrastructure, Transport and Tourism is expected to implement the proper management to promote these activities steadily.

1. Preface

A series of derailment accidents of freight trains composed of container-carrying wagons, occurred in Esashi Line, denoting in the following text as "the Esashi Line derailment accidents" which is a set of three accidents, i.e., "Esashi I" accident occurred on April 26, 2012[1], "Esashi II" accident occurred on September 11, 2012[2], and "Esashi III" accident occurred on June 22, 2014[3], have the common situation that the outer rail side wheels of the freight wagon in the freight train running in relatively sharp curve at near the limited speed, derailed by flange climbing, denoting as “Flange climb derailment accidents of freight wagon”, in the following text. As the probable causes of these accidents are described in each investigation report, it is probable that these accidents were caused by complex combination of the factors, such as vehicle, track, loading freight etc.

The results of analyses about "the Esashi Line derailment accidents" and the similar accidents occurred in the past, and the issues towards measures to prevent recurrence of the accidents required to examine in the future, are shown in the following text.

(Refer to the Attached table "Summary of the Esashi Line derailment accidents")

2. Flange climb derailment accidents of freight wagon and alredy implemented measures to prevent derailment

Figure 1 shows the data about flange climb derailment accidents and the similar accidents occurred after 1952[4]-[6]. The flange climb derailment accidents of freight wagons at main tracks had occurred frequently until around 1980, and probable causes of these accidents were determined as combination of various factors while the vehicles and the tracks were maintained within the criterion values for control, and so called as "multiple-factor derailments". The Tsurumi accident, occurred in Tokaido Main Line in November, 1963, was the multiple collision accident originated by derailment of freight wagon, and became to the disastrous accident killing 161 people. To respond this accident, Japan national railway, at that time, established the investigate committee to conduct a variety of examination including on-track tests, and implemented the measures to prevent multi-factor derailments from the view points of both vehicle and track[7], i.e., softened spring constants of the secondary suspension of the TR-41 series bogie, remodeled to use with oil dampers, added the combination of alignment and cross-level to the items in the management of track irregularity, etc. As the results of implementation of these measures, there was no multiple-factor derailment accident after 1982, however, in recent years, the same sort of derailment accidents came to happen again.

As shown in Table 1, seven accidents of the same sort of derailment occurred from 1998 to the present, and the recent three accidents occurred at Esashi Line. Here, Esashi Line became to the track section where freight trains run very frequently after connected with Kaikyo Line in 1988, has the features that there are many relatively sharp curves. Generally, margins against derailment is reduced in the curved section of small radius with large track irregularity, then it is somewhat likely that there were the trends liable to reduce margins against derailment in Esashi Line, compared with the other section. Here, although further precise analyses are needed, it is required to investigate on the same sort of derailment in the track sections where freight trains are operated, as it is considered that these situation is not peculiar to Esashi Line only.

The types of the derailed freight wagons were Ko-Ki 106, Ko-Ki 107 and Ko-Ki 200*. All of them are relatively new type freight wagons manufactured after 1997, i.e., the first Ko-Ki 106 type freight wagon was manufactured in 1997, the first Ko-Ki 200 type wagon was manufactured in 2000, and the first Ko-Ki 107 type wagon was manufactured in 2006.

* "Ko-Ki" : "Ko" means freight wagon for containers, "Ki" means loading capacity over 25 tons.

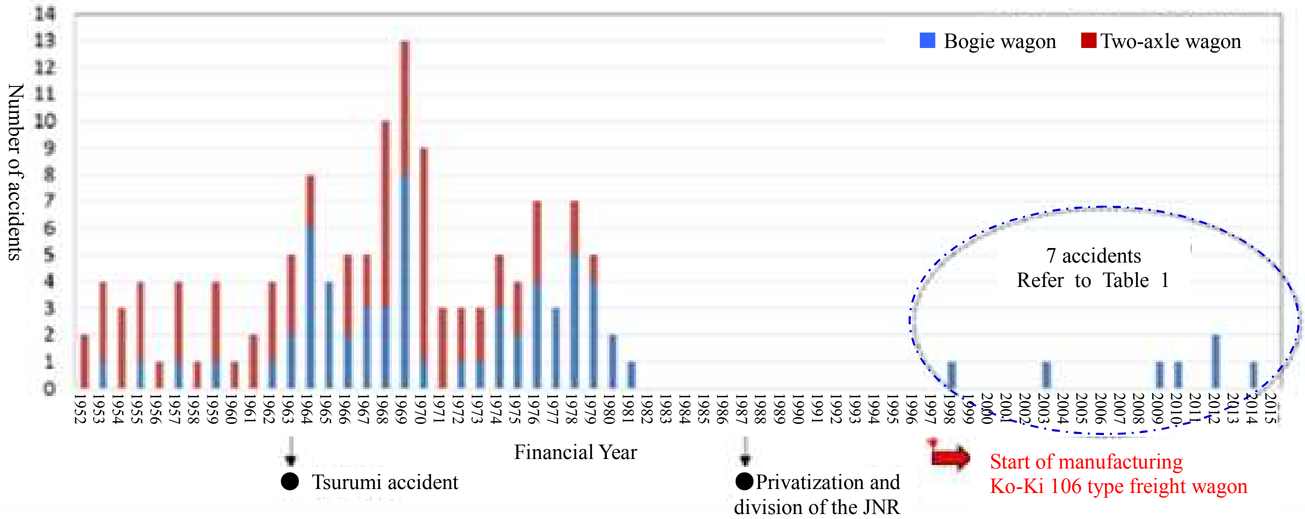

Figure 1 Changes of flange climb derailment and similar derailment accidents of freight wagon.

Table 1 Recent flange climb derailment accidents of freight wagon

No	Date of accident	Line name	Accident site	Wagon type	Velocity	Radius of curve	Operators * (vehicles - track)	Remarks
1	Aug. 26, 1998	San-yo Line	Between Seno station and Hachihommatsu station	Ko-Ki 106	55 km/h	300 m	JR Freight - JR West	
2	May 22, 2003	Tokaido Line	In the premises of Tokyo Freight Terminal station	Ko-Ki 106	42 km/h	About 268 m	JR Freight -JR Freight	# Simple turnout No.12
3	Dec. 19, 2009	Nippo Line	Between Sotaro station and Ichitana station	Ko-Ki 200	60 km/h	300 m	JR Freight - JR Kyushu	
4	Mar. 10, 2011	Narita Line	Between Kuzumi Station and Namegawa station.	Ko-Ki 200	57 km/h	406 m	JR Freight - JR East	
5	Apr. 26, 2012	Esashi Line	Between Izumisawa station and Kamaya station	Ko-Ki 107	57 km/h	300 m	JR Freight - JR Hokkaido	"Esashi I"
6	Sept. 11, 2012	Esashi Line	Between Kamaya station and Izumisawa station	Ko-Ki 106	59 km/h	300 m	JR Freight - JR Hokkaido	"Esashi II"
7	Jun. 22, 2014	Esashi Line	Between Izumisawa station and Satsukari station	Ko-Ki 107	63 km/h	350 m	JR Freight - JR Hokkaido	"Esashi III"

* JR Freight : Japan Freight Railway Company, JR West : West Japan Railway Company, JR East : East Japan Railway Company, JR Kyushu : Kyushu Railway Company, JR Hokkaido : Hokkaido Railway Company.

3. Toward prevention of recurrence.

It is probable that the Esashi Line derailment accidents were caused by complex combination of the factors, such as vehicle, track, loading freight etc., as their degrees of influence differ in each accident. In this chapter, analyses are implemented about issues to be investigated, related with vehicle, track, and loading freight, that the party concerned should grapple in cooperated with each other, to improve margins against derailment as a whole, to prevent recurrence of the same sort of the accidents and further improvement of running safety of the freight train, based on the analyzed results about vehicles, track, and loading freight in the Esashi Line derailment accidents.

[Refer to the Attached diagram "Factors of the Esashi Line derailment accidents and their degrees of influence, etc."]

3.1 Issues related with vehicles.

According to investigation results about the accidents "Esashi II" and "Esashi III", it was found that Ko-Ki 106 type freight wagons and wagons manufactured after that still used coil spring type secondary suspension with enlarged spring constant as to load heavy international ISO standard type containers, etc., under restriction of height of the couplers, responding the needs such as higher efficiency, faster speed, and internationalization in the freight transport market, while the bolster dampers were designed to select conventional devices aiming to use common parts.

When the freight wagons of these types run on the track where there is combination of alignment and cross-level having the property to excite rolling motion of vehicle bodies largely, there are the cases to decrease running safety by the significantly decreased dynamic wheel loads due to enlarged rolling notion of the vehicle body, compared with the freight wagons equipped with smaller spring constant type secondary suspensions[8]-[12]. It was found from the investigation results of the accident "Esashi II", that there exists "the disadvantageous situation against running safety", in which the damping characteristics of the bolster damper could not demonstrate its ability well according to situation of loaded freight, and this trends become remarkable especially in Ko-Ki 106 type freight wagons and wagons manufactured after that. Here, in the "Esashi II" accident, it is probable that the freight wagon derailed by the combination of relatively large combination of alignment and cross-level in relatively sharp curve, relatively light loaded freight and their gravity center was in higher position, in addition to above mentioned factors.

Then, as for the vehicle, the parties concerned should investigate to use the suspension device with proper damping characteristics and to equip suspension device which can obtain proper damping characteristics regardless of quantity of loaded freight, referring to methods of freight loading and situation of the track section where freight trains are operated, etc., to realize safe operation of the concerned freight wagons with proper margins against running safety.

3.2 Issues related with Tracks

It is considered that the decreased wheel load promoted by the large combination of alignment and cross-level will effect relatively large as the factors related to tracks in the probable causes of the flange climb derailment accidents of freight wagons.

The management system for combination of alignment and cross-level was investigated and implemented for bogie wagons using TR41 series bogie or two-axle wagons of Wa-La-1 type, etc., as one of the measures preventing recurrence of multiple-factor derailment described in the above Chapter 2, and was introduced in around 1980, in almost the same contents with the present system. The present management system can be estimated as effective at a certain level, because the multiple-factor derailment accidents were extremely reduced after the present management system was introduced, and the similar accidents did not happen until recent years, provided that the freight wagons, which were the target of improvement at that time, became not in use at present.

On the other hand, a part of flange climb derailment accidents of freight wagons, occurred in recent years, were caused by the combination of alignment and cross-level which were not satisfied the values of the maintenance standard. It is suggested that there is the possibility to reduce margins for safety by the management methods covered by the present management system of combination of alignment and cross-level, provided that there are the other factors than the track, for example, unbalance of loaded freight in the accident "Esashi I" and lack of damping in suspension device in the accident "Esashi II".

Then, in the issues related with track, in addition to implement proper management of combination of alignment and cross-level based on the present management system, including general measures such as investigation about the range to install guard angle, the parties concerned in railway operators and research institutes are required to investigate the management system of track irregularity in the section where freight trains are operated, considering the characteristics of freight wagons based on characteristics of track section and loading methods of freight loads.

3.3 Issues related with loading freight

In the issues related with loading freight, there are issues such as unbalanced loading of freight and height of the gravity center of loaded freight.

As for the unbalanced loading of freight, the following measures are described in the investigation report about “Esashi I” accident, these are, Japan Freight Railway Company asked the transport operators using railway to let noticed their employees well the context of the contract on freight transport such as prevention of unbalanced loading and confirmation of loaded status, and Japan Freight Railway Company will confirm the status of loaded freight in corporation with the transport operators using railway, from viewpoints of preventing unbalanced loading in the containers to avoid large unbalance of static wheel weight in freight wagons. In response to these activities, at present, the Ministry of Land, Infrastructure, Transport and Tourism and the operators concerned established "Investigation meeting on measures against unbalanced loading in railway freight transport", and the measures at a certain level were implemented based on the intermediate summaries of the meeting.

As for the height of the gravity center of loaded freight,

it was found by the investigation results on the accident "Esashi II" that

there is the case that rolling motion of the vehicle can not be damped well by poor damping characteristics when the weight of loaded freight is relatively light, due to the switching condition of damping characteristics of the bolster damper of freight wagons, and the margins against derailment will be reduced when the gravity center of vehicle body is high even when weight of loaded freight is relatively light, in these situation.

Then, as for the issues related with loading freight, the "Investigation Committee on measures against unbalanced loading in railway freight transport" is expected to investigate successively about introduction of the system that can detect easily the unbalance of wheel weight of the wagon loaded containers, in addition to the measures to prevent unbalanced loading. Furthermore, the meeting is also required to investigate the loading methods considering weight and the height of the gravity center of loaded freight, adding the characteristics of the freight wagon in operation.

4. Conclusion

Railway is the integrated system of various technology areas, such as civil engineering, vehicle technology, electric engineering, operation, etc., then it is very important to obtain safe operation that every technology divisions corporate with each other. In the railway freight transportation, the passenger railway operators charged with track maintenance etc., the freight railway operators charged with vehicle management and operation etc., the freight transporters and the freight senders charged with loading freight, and the railway vehicle makers manufacturing the freight wagons, are related.

After this, the research institutes in addition to these parties concerned with freight transport are requested to grapple with each other towards the further improvement of running safety of freight trains, obtaining proper margins against derailment as the whole, considering possibilities of realization based on the status of characteristics and operation of freight wagons, and the status of track maintenance etc., in the investigation of various issues including the issues analyzed in the previous Chapter 3. Ministry of Land, Infrastructure, Transport and Tourism is expected to take proper responses to promote steady implementation of these activities.

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Attached table. Summary of the Esashi Line derailment accidents

	Esashi-I (Occurred on April 26, 2012)	Esashi-II (Occurred on September 11, 2012)	Esashi-III (Occurred on June 22, 2014)
Track	Left curve of 300m radius with 100mm cant.	Right curve of 300m radius with 100mm cant.	Left curve of 350m radius with 90mm cant.
	Enhancement of track strength and minor improvement of track shapes were implemented in the construction works improving Esashi Line from class 4 (Hei) to class 2, along with connection to Kaikyo Line.		
Wagon type	Ko-Ki 107 type	Ko-Ki 106type	Ko-Ki 107 type
Derailed vehicle	18th vehicle of 20 vehicle train set.	9th vehicle of 21 vehicle train set.	20th vehicle of 21 vehicle train set.
First derailed axle	Front axle in the rear bogie (3rd axle)	Front axle in the rear bogie (3rd axle)	Front axle in the rear bogie (3rd axle)
Velocity	About 57 km/h	About 59 km/h	About 63 km/h
Probable causes	It is probable that the outside rail side wheel climbed up to the top of the rail and derailed, due to the increased derailment coefficient for the outside wheel, because the lateral force acting on the outside wheel had increased by the increased wheel load of the inside wheel, and the wheel load of the outside wheel had decreased, due to the large unbalance in the static wheel loads between right and left wheels of the freight wagon loaded containers, compared to the wagon with balanced static wheel load, while the train passed in the curved track of 300m radius, in this accident. It is highly probable that the unbalanced loading in the containers caused the large unbalance in the static wheel loads in the derailed freight wagon. In addition, it is somewhat likely that the combination of alignment and cross-level, which should be managed in the section where freight trains are operated, had relatively large at the point before the wheel started to climb up, promoted the decrease of wheel load of the outside wheel.	It is probable that the accident occurred because wheel loads of outer rail side wheel in the first axle in the rear bogie of the Ko-Ki 106 type freight wagon was decreased at around the accident site, while the train passed the 300 m radius right curved track, and the wheel climbed up the outer rail and derailed. It is probable that the wheel load acting on the outer rail side wheel reduced by a large rolling vibration of the freight wagon running around the accident site. Although statuses of the train operation, the maintenance of the vehicles and the railway track were implemented in accordance with the regulations of Japan Freight Railway Company and Hokkaido Railway Company, established based on the ministerial ordinance, it is probable that the freight wagon vibrated in rolling mode significantly by the combination of the following factors. [1] The specification of the suspension device of the Ko-Ki 106 type freight wagon was that the rolling motion of the vehicle body would not converged in a short time, as the damping was small compared to the Ko-Ki 104 type freight wagon, when the loaded weight is relatively light. [2] The load was relatively light and the center of gravity of the freight wagon was in a high position. [3] The combination of alignment and cross-level at around the accident site, which were relatively large as close to their maintenance standard values, and were distributed along the track including the wave length components liable to introduced rolling motion of the body against the train velocity, had possibilities to promote the generation of rolling motion of the body.	It is somewhat likely that the accident occurred as the outer rail side, right, wheel of the Ko-Ki 107 type freight wagon, climbed up the rail and derailed to right because the derailment coefficient increased due to the decrease of the wheel load and increase of the lateral force for the outer rail side, right, wheel, as the body of the freight wagon was excited to vibrate in rolling mode significantly while the train was running in the 350 m radius left curved track. It is probable that the significant roll vibration was excited to the vehicle body due to the existence of the large combination of alignment and cross-level which should be maintained, in the track before the point where the wheel started climbing up the rail. It is somewhat likely that the existence of the large alignment to shorten the radius of curvature effected to increase the lateral force in the outer rail side wheels. It is somewhat likely that the large combination of alignment and cross-level which should be maintained had existed because the on-site track maintenance section could not understand the existence of the plural kinds of the combination of alignment and cross-level measured by the high speed track inspection car, and these situation was caused in relation with the improper method to decide the necessity of the maintenance work by communication of the inspected results to the on-site track maintenance section, and a lack of the knowledge about the combination of alignment and cross-level in the on-site track maintenance section. Although it could not be determined whether the unbalanced loading actually related to the occurrence of derailment, it is somewhat likely that the status of loading just before the accident became to a factor to promote derailment.

Attached diagram. Factors of the Esashi Line derailment accidents and their degrees of influence, etc.

○ A series of the derailment accidents of freight trains occurred in Esashi Line have the common situation that the outer rail side wheels of the freight wagon in the freight train running in relatively sharp curve at near the limited speed, derailed by flange climbing.

○ It is somewhat likely that these accidents were caused by the combination of the factors such as vehicles, track, and loading freight, etc., in the worse direction, while each factor would not cause the derailment.

○ Here, degrees of influence of the factors to a series of derailment accidents differ as shown in the followings.

Vehicle

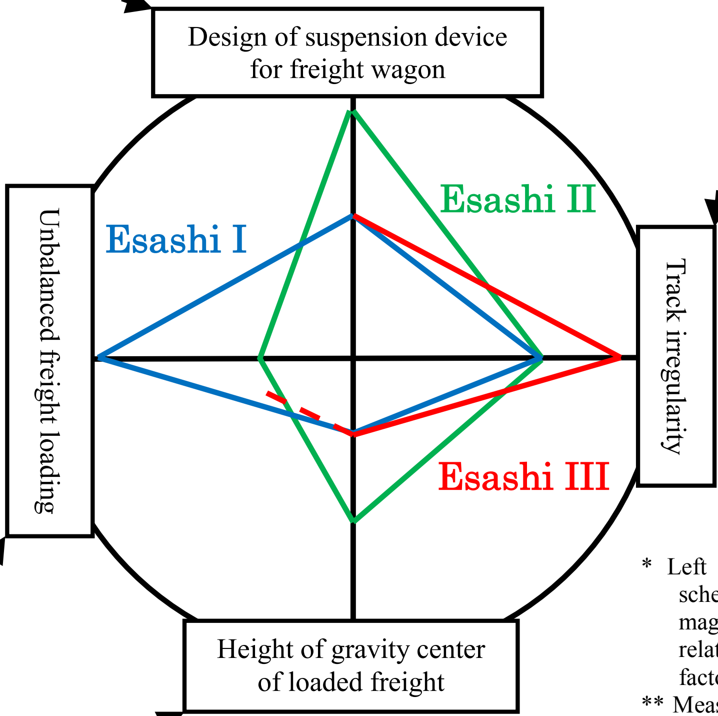
[Factor] Design of suspension device of freight wagon

Design is liable to decrease wheel load by effects of spring constant or damping ratio for rolling mode. This phenomenon is caused remarkably in case of relatively light weight load corresponding to around switching position of damping coefficient of bolster damper.

[Measures to prevent recurrence]

- Investigate to use suspension device in the range of proper damping characteristics area and to equip the suspension device with proper damping characteristics regardless of quantity of loaded freight.

Images of degree of influence of factors



* Left figure shows degree of influence of each factor schematically. Distance from the center indicates magnitude of relative degree. Here, magnitudes of relative degrees do not indicate comparison with another factors.

** Measures to prevent recurrence include a part of already implemented items.

Track

[Factor] Track irregularity

- Large combination of alignment and cross level promote decrease of wheel load.
- Large alignment promote increase of lateral force.

=> Combination of alignment and cross level largely effect to decrease wheel load.

[Measures to prevent recurrence]

- Manage the combination of alignment and cross level properly.
- Investigate more effective management method of track irregularity corresponding to operating status of freight wagons and trains.

Loading freight

[Factor] Unbalanced freight loading

Unbalanced loading of freight increase static wheel load ratio and promote decrease of wheel load.

[Measures to prevent recurrence]

- Investigate and implement measures preventing unbalanced loading.
- Investigate introduction of systems that can detect unbalanced wheel loads of freight wagons loaded containers.

[Factors] Height of gravity center of loaded freight

Rolling vibration is excited due to the high position of gravity center and promote to decrease wheel load.

[Measures to prevent recurrence]

- Investigate methods of loading freight considering characteristics of freight wagons in operation.