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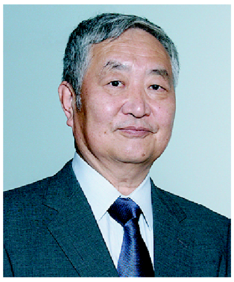
Technology Towards a Safe and Secure Society

The Need for the Study of Failure - What we learned from the "Door Project" -



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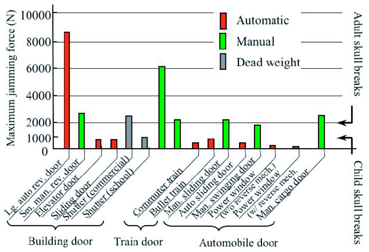
Introduction

1. Looking at failures differently

We have in the past looked upon failures as bad things that we should avoid, however, the author conceived that such a way of thinking has been responsible for repeating the same failures and proposed a novel idea; the "Study of Failure." This paradigm distinguishes "excused failures" and "unexcused failures."



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Analysis of Railway Vehicle Behavior in Earthquake

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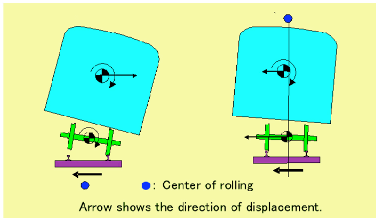
Introduction

1. Introduction

In a railway system, there are many problems regarding safety such as derailment, turnover, fire and collision, which are caused by troubles of vehicle and/or track and human errors, and sometimes natural disasters deteriorate the railway safety.In Japan earthquake is one of the biggest natural threats for the railway and actually Shinkansen vehicles running at 200km/h derailed in



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Incident Analysis of Road Transport

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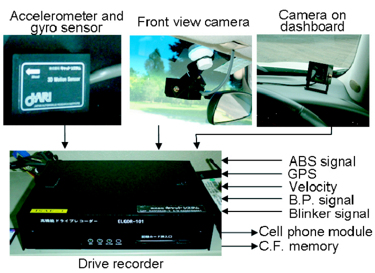
Introduction

INTRODUCTION

Statistical data shows that 6,871 people were killed in traffic accidents, and approximately 1.2 million people were injured in Japan in fiscal 2005. As serious social problems of the nation, it causes totally over 4 trillion yen of economic loss. In order to reduce traffic accident-casualties, it is necessary to investigate causes that induce the accidents.



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Report on Completion of Commemorative Lecture and Ceremony for Establishment of "Machine Day and Machine Week"

Introduction

The commemorative lecture and ceremony for the establishment of "Machine Day and Machine Week" was held on August 7th (Mon) in the Faculty of Engineering, Bldg. 2, at the University of Tokyo, attended by many guests and representatives of the various groups concerned, and members of JSME.

Objectives of Establishment of "Machine Day and Machine Week"

The progress of technology has contributed to the development and deepening of civil culture, but it has also brought

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The Need for the Study of Failure - What we learned from the "Door Project" -

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Continued from page 1 Excused failures are results from new challenges by individuals or organizations and are inevitable for our growth and advancement. On the other hand, repeating the same mistake that one had already faced in the past and could have been avoided if he had been careful, is an unexcused one. Our denial of failures without this distinction has caused us to unnecessarily repeat the same failures.

2.The Door Project

In March 2004, a six-year-old boy was jammed and died in a large automatic revolving door at the entrance of a skyscraper in Roppongi, Tokyo. This accident, as Figure 1 shows, caught the boy's head between the revolving door and the fixed column and killed him. Naturally, the police investigated the cause of the accident. The cause analysis, however, by the judicial officers were naturally for the purpose of prosecuting the responsible and not about preventing the reoccurrence of the accident. The author thought that mixing up the prosecution and cause analysis in such a way leads to repeating the failure, and thus initiated a private project of identifying the causes(1)(2).

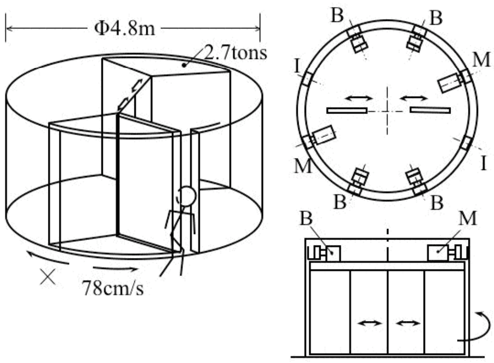

Fig.1 Automatic revolving door that caused the accident

A number of people with a variety of occupations from different organizations participated in the "Door Project" and carried out verifying tests for all types of doors with the actual machinery to clarify the phenomenon of a human getting caught. Doors that were subjected to the project were building doors including large and small-size revolving doors, sliding doors, swinging doors, elevator doors and shutters, and automobile doors including sliding doors, swinging doors, and automatic windows, and train doors on local cars and bullet trains. We built dummies installed with force sensors and held them to simulate the human posture and caught them with these doors to measure the phenomena. Photo 1 shows a high-speed photograph of a dummy caught in a large-size revolving door.

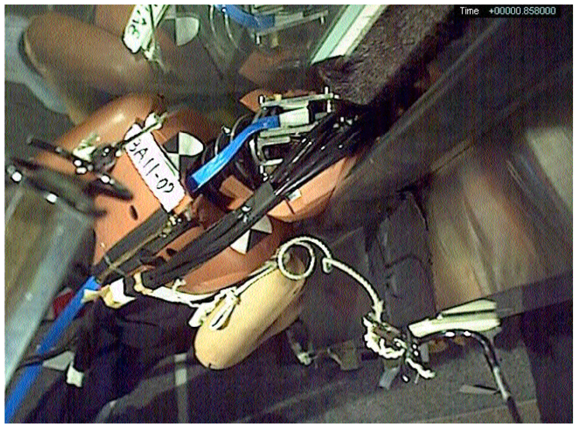

Photo1 High speed camera image (2004-10-21)
Dummy head was caught, twisted and squeezed and the neck is pulled.

This experiment captured the video of the head getting caught, twisted and squeezed between the column and the door, and recorded the dynamic force generated during the event.

3.Lessons learned

We learned a number of lessons through this project, some of which are listed below:

(1)Inertia, dead-weight, and lever: There are three mechanisms, inertia, dead-weight, and lever that generate force at the door.

(2)Manual operation is more dangerous than automatic: Figure 2 shows magnitudes of forces generated when a stiff force sensor was jammed between doors and their frames. The hatched bars are from manual operation, and white bars are from automatic. The figure shows the doors, when manually operated, generated fatal force (we assumed 2,000N for adults and 1,000N for children(3)) whereas automatic ones generated small

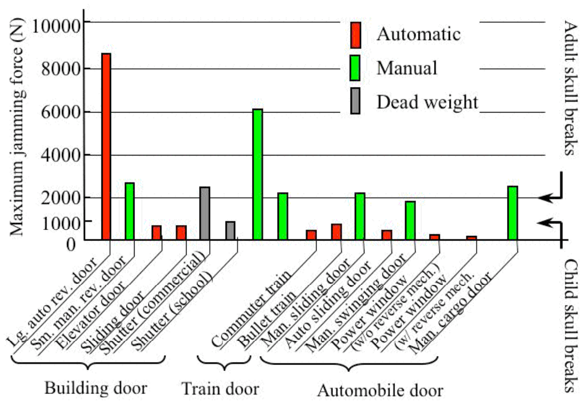

Fig.2 Maximum jamming force when the doors jammed the bare sensor

forces except the revolving door. These results show that manual operation is more dangerous than automatic. We tend to think the other way, which is a misconception.

(3)Tacit knowledge: We found that each field has tacit knowledge that anyone who is in the field knows about but is not expressed in words. In case of sliding doors, for example, engineers who work with elevator doors or entry doors had the knowledge of "the rule of 10 Joules" meaning that when a moving door exceed 10 Joules, it can cause a fatal accident. Engineers that work with other types of doors, however, not at all acknowledged this knowledge. This fact tells us the importance of expressing tacit knowledge.

(4)Genealogy of technology: Figure 3 shows the importance of the genealogy of technology. Designers in

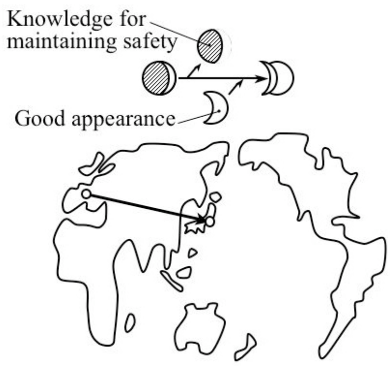

Fig.3 Genealogy of Technology
- Important factors were lost and unimportant factors were added when the technology came to Japan. -

Europe, in designing the same size (4.8m) doors knew that "doors have to be light, otherwise they are dangerous," however, when the technology reached Japan, the mass of the revolving part tripled for better looks and high rigidity needed at the entrance of skyscrapers. We found that it was the root cause of the accident. We thus learned the importance of reviewing the genealogy of technology when we adopt a new one. Another factor that leads to accidents are "additive designs" that keep adding mechanisms to meet requirements that come up one after another.

(5) "Controlled safety" and "Inherent safety" : We need to think through the relation between controlled safety and inherent safety. The large-size revolving door had a big mass and frequent accidents that caught people. The owners kept being preoccupied with the countermeasure of installing sensors to stop the door before it hit people. Trying to overcome the danger with controlled safety with sensors, without reverting to the inherent safety lightening the door, was a factor of the accident. We should first accomplish inherent safety, and then add controlled safety over it for added convenience. The idea of leaving potential danger untouched and covering it with controlled safety is a

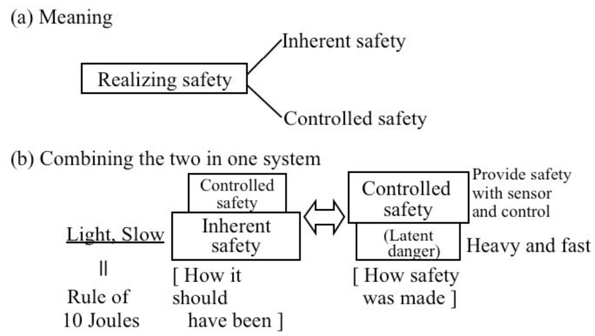

Fig.4 Inherent safety and controlled safety

mistake (Figure 4).

4.Preventing future accidents

The study of failure has been voicing a number of claims. Here are some for reference:

(1)What can happen does: No matter how low the probability of occurrence may be, events that we can think of do take place. Even with low frequencies, we, during the design phase, have to take into account those events that lead to severe results as possible accidents. Here the requirement on the designer is ample creativity. The designer especially has to plan on malfunctions or breakage of his designs.

(2)People have changed: We used be alert about various dangers that surrounded us through our daily lives. As we got used to being surrounded with safe machines, our danger-sensing zone has narrowed and we are no longer sensitive to dangers that are next to us. Machine operators have to know to protect their own bodies, and the designers should learn that users that operate machines are no longer as sensitive to danger as they used to be

(3)Transfer knowledge about accidents in visible forms: When machines that have caused accidents are gone, so are people's memories about the events. For the society to keep the memories and later designers and manufacturers to learn about the events, it is best to preserve the machines in states that they operate (dynamic preservation). The large-size revolving door that had the accident is dynamically preserved by the cooperation between the manufacturer Sanwa-Tajima, and the owner Mori-building so that the next generation engineers can learn from it.

5.Accidents Continue to Happen

The author and his group have been wildly sending messages through TV, newspaper, journals and other publications, so that the lessons of failures will help the society. Even so, similar accidents continue to take place. The followings are some of them:

● Another jamming accident: When a high school student was about to exit an elevator in a residential apartment complex in Minato-ku, Tokyo, the elevator started to ascend with its door open jamming the boy between the floor and the building side ceiling. It was indeed a jamming accident. If the way of thinking gained from the Door Project was widely spread and been known to the users or the managers, perhaps this incident could have been avoided. The root cause of this accident was the design, manufacture, and use of such a dangerous elevator. The elevator had quadruple safety mechanisms for the drop of the cage, however, only a single or double safety mechanisms for the ascending direction. The designer probably did not think about the accident of the cage automatically going up.

● Change in the human and machine responsibility areas: Accidents take place in gaps among areas that human are responsible for and those that machines are responsible for. After an accident, technology advances to cover the gap to make it a safe area. As we, however, get used to being surrounded by safe areas the area we think that we have to take responsibility in narrows and then gaps emerge again. Accidents then take place again in these gaps. It is most important for managers and users as well as designers and manufacturers to understand the phenomenon of the narrowing of the human responsible areas in the modern world. Without these people having the proper way of thinking, accidents will continue to happen. It is strongly desired that the Study of Failure widely spreads to the society.

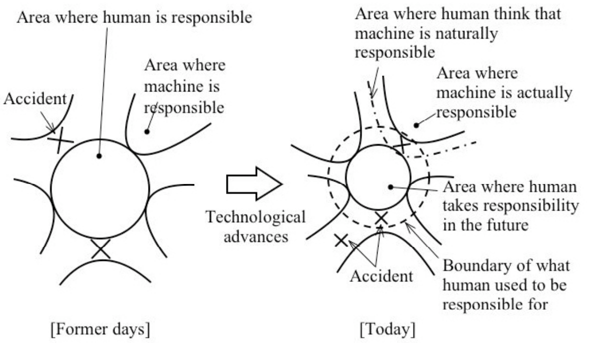

Fig.5 Mismatch of human and machine responsibility areas caused by advancement of Technology

If the way the Study of Failure teaches is insufficient, maybe in the future, we need "The Study of Danger" to handle dangers that directly affect human.

Acknowledgment

The "Door Project" was carried out with the cooperation of many corporations and individuals. Based on the knowledge from the project and with the funding from Secom Science and Technology Foundation, we are continuing the research with students in the Department of Basic Engineering in Global Environment at Kogakuin University pursuing the theme of "Building miniature models of revolving doors that are not dangerous."

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Analysis of RailwayVehicle Behavior in Earthquake

Yasufumi Suzuki
Railway Technical Research Institute

Continued from page 1the Mid Niigata Prefecture Earthquake in 2004 (Fig.1). Although fortunately there were few damages for passengers and crews in the derailment, the accident of a high-speed Shinkansen train affected the Japanese society and increased awareness of necessity of raising the safety level of Shinkansen.

In this article research activities regarding the vehicle behavior analysis conducted in Railway Technical Research Institute (RTRI) are described, which are conceivable to be a basis of considerations concerning the safety in an earthquake.

2.Analysis methods for vehicle behavior in earthquake

After the South Hyogo Prefecture Earthquake in 1995, the earthquake-resistant design standard of railway structures has been reviewed and enhanced and analysis methods for the vehicle behavior on shaking structures in an earthquake have been developed. In the analyses the large

Fig.1 Derailed Shinkansen Cars

deformation of springs and dampers in a vehicle and the phenomena of loosing and getting wheel/rail contact have to be taken into account as precisely as possible. RTRI has developed two calculation programs for the analysis of vehicle behaviors in an earthquake.
One of them is the Vehicle Dynamics Simulator (VDS), which considers the deformation characteristics of springs and dampers and creep forces in detail for a few number of cars and the other is the Dynamic Interaction Analysis for Shinkansen Train and Railway Structure (DIASTARS), which treats the behaviors of trains and structures taking account of dynamic interaction between them.

3.Analysis by VDS

VDS calculates the vehicle dynamics using a model as shown in Fig. 2. In the case of a bolsterless bogie, the followings are considered: a carbody, a bolster, a bogie frame and a wheelset are rigid bodies and the total degree of freedom is 58. The track information about geometry and irregularity and the track displacement by an earthquake are used in the analysis.
Fig.3 shows the running safety limit, which means the track lateral amplitude at which the derailment occurs on the track vibrating in five sinusoidal consecutive waves with each frequency. The safety limit is lower in a higher frequency. Vehicle behaviors vary depending on the exciting frequency, whose typical vibration modes are as shown in Fig.4. Under approximately one Hz, the left and right wheels are apart from rails alternately and over around 1.5 Hz a wheel flange hits a rail shoulder to jump over the rail.
The validity of this analysis was proved by a vibrating test using a full size Shinkansen bogie.

4.Analysis by DIASTARS

As shown in Fig.5 DIASTARS is a three-dimensional calculation program applicable to arbitrary railway structures. In the program, a car is modeled using rigid bodies of a carbody, bogies and wheelsets and springs and dampers connecting those bodies, and tracks and structures are expressed by various kinds of finite elements.
Originally DIASTARS has been developed as an analytical tool for ride comfort and running safety in a normal condition to be utilized for the design of structures. In order to analyze the phenomena such as a large deformation of structures, a large movement of vehicles and no contact between wheel/rail, which are peculiar to an earthquake condition, some improvements have been introduced.
As shown in Fig.6 in the program a column or a pier is replaced with one spring which has a deformation-load characteristics equivalent to that calculated by a detailed model. Fig.7 shows how a non-linearity due to a large deformation of structures affects the running safety limit.

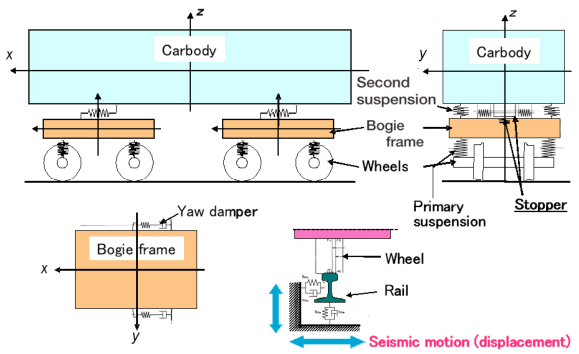

Fig.2 Vehicle Dynamics Model (VDS)

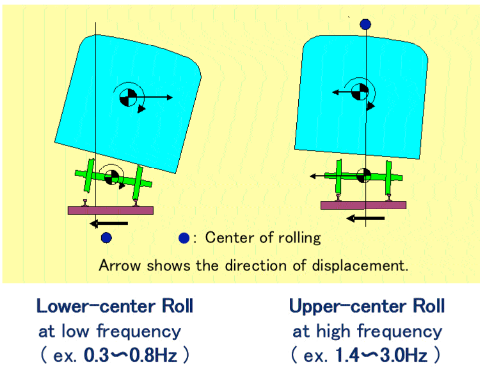

Fig.3 Vehicle Dynamic Behavior on Vibrated Track

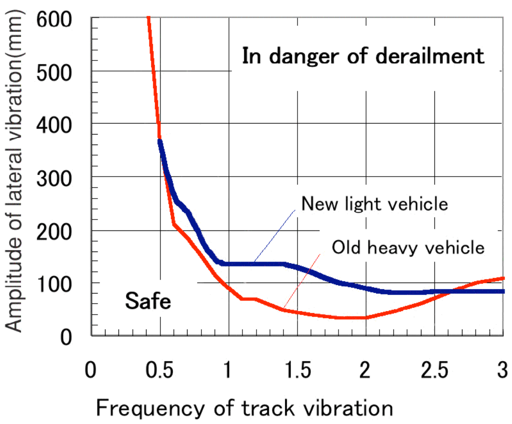

Fig.4 Running Safety Limits (Simulation)

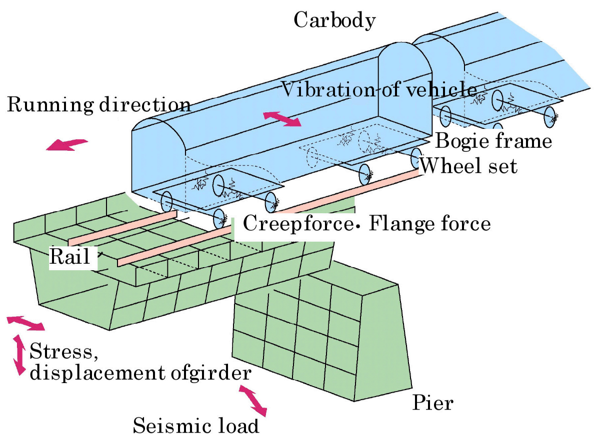

Fig.5 Vehicle Structure Dynamics Model (DIASTARS)

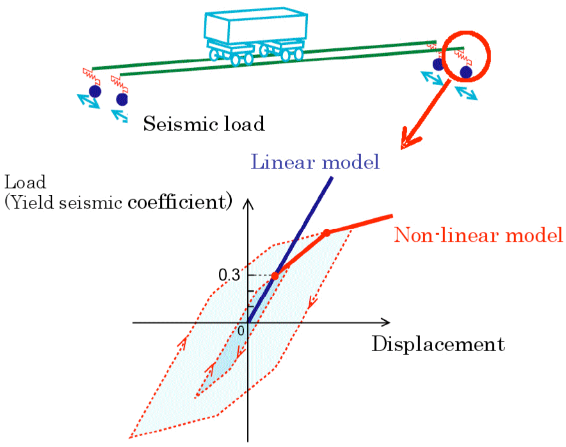

Fig.6 Non-linear Load-Displacement Characteristics

The vertical axis is the ground acceleration value at which the derailment occurs while the amplitude of a seismic wave for a structure design increases. In the case of taking account of the non-linearity of structures, the safety limit is higher, which is evaluated as safer, than the linear case because the acceleration of structures is restrained due to a large plastic deformation of the structure.

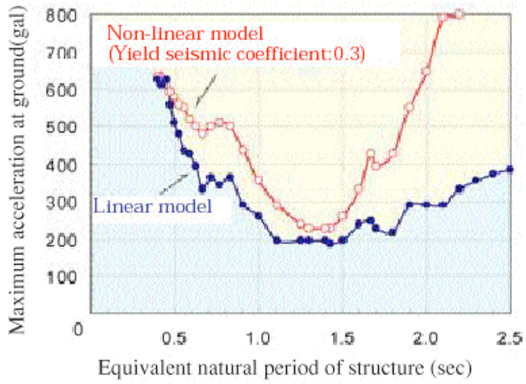

Fig.7 Running Safety Limits (Simulation)

5. Conclusions

After the derailment accident of Shinkansen, the countermeasures for the safety of Shinkansen railway system in an earthquake have been discussed in the Ministry of Land, Infrastructure and Transportation. Further research themes regarding the running safety in an earthquake are the problems such as the safety when running on different structures on different ground conditions and the analysis of vehicle behaviors after derailment.

Incident Analysis of Road Transport

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Continued from page 1From the viewpoint of scientific approach to this problem, the effective way is to detect and study not only accidents but also incidents utilizing drive recorder. Drive recorder is capable not only to act as a witness when accident occurs, but also to utilize its valuable information to the design and development of active safety system [1-3]. The contents of this article is to describe the background and the importance of strategies for reducing traffic accident casualties, the synthesis of scientific approaches for promoting road traffic safety, and the cooperation of G.I.A.(Government/Industry/Academia), as well as the recent activities conducted by Society of Automotive Engineers of Japan(JSAE).

2. IMAGE-CAPTURED DRIVE RECORDER

Recently, in the field of automobiles, the event data record devices at crash called "Drive Recorder" have been developed. As an example, Figure 1 shows the components of drive recorder specially developed in our research project. Drive recorder can capture front-view image with front-view camera and driver-view image with camera on dashboard. The drive recorder equips motion sensor for measuring of accelerations and angular velocities. Vehicle cruising velocity and position data with GPS module are obtained. The drive recorder additionally equips ABS signal detector. When large deceleration exceeds a certain limit or ABS is activated, the drive recorder captures 10-second data before trigger and 5-second data after trigger. The collected data are stored in compact flash memory. Figure 2 shows the detail of actually captured data from drive recorders. As shown in the movie data and the obtained sensor data, detailed analysis and quantitative evaluation of dangerous situation is possible.

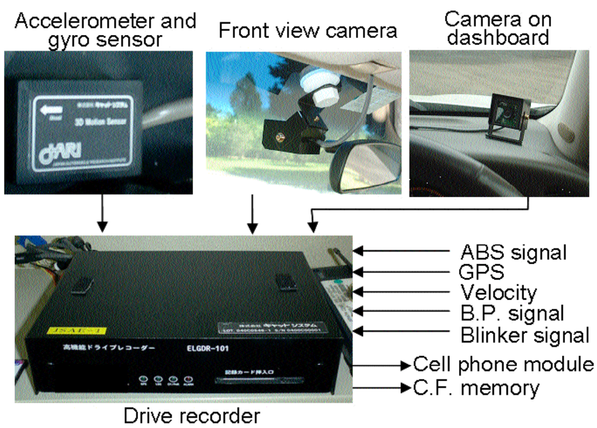

Figure 1 - Drive recorder (High performance type)

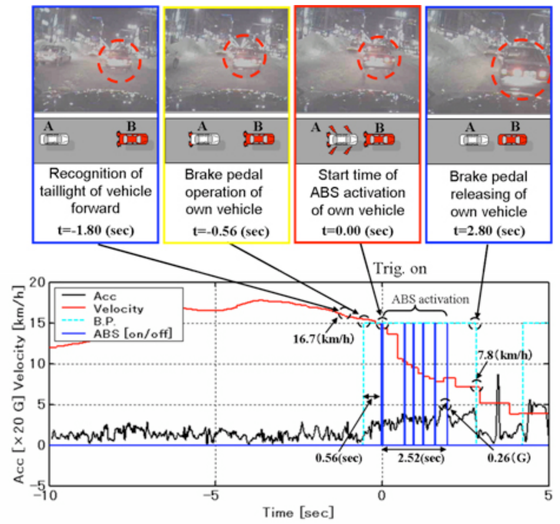

Figure 2 - Time history of near-miss incident on snowy road.

3. ACTIVITIES OF INCIDENT ANALYSIS

In 1931, H. W. Heinrich surveyed approximate five hundred and fifty thousand accidents and found that, for one fatal or serious accident, there were 29 accidents, and 300 potential incidents containing high possibility to cause injuries. This Heinrich's law is also instructive for traffic accident analysis. The authors are investigating the traffic accident prevention effect by using drive recorder and making a survey of "real-world incidents" in the project hosted by JSAE under the grant of Ministry of Land Infrastructure and Transport. As a part of the project, the incident-captured drive recorder is being developed and used for survey research. The Incident Analysis Working Group of JSAE was established in August 2004. The major achievements to be drawn from the activities can be summarized as follows:

(A) Implementation of prototype drive recorders: The two types of drive recorders, widespread type (simple and low cost type) and high-performance type, were made. The aim of high-performance type is focus on developing new type of drive recorder which can collect more useful incident related to active device working situation. Hence, driver's image, yaw rate, auxiliary channels are added in the high-performance type. 55 widespread type (35 taxis) and 15 high-performance type (14 taxis) were implemented.

(B) Database construction: More than 10000 incident data from 35 taxis equipped with widespread type drive recorder were collected. The number of incident is equivalent to 1.5 times per 1000 km running. In addition, large-scale database construction was conducted for data reading and analysis, and the validation of function and data analysis were carried out. Currently, about 3300 incident data are put into the database. Figure 3 shows the outline of database.

(C) Incident Analysis: By using the collected incident data, incident macro analysis to get information of relation

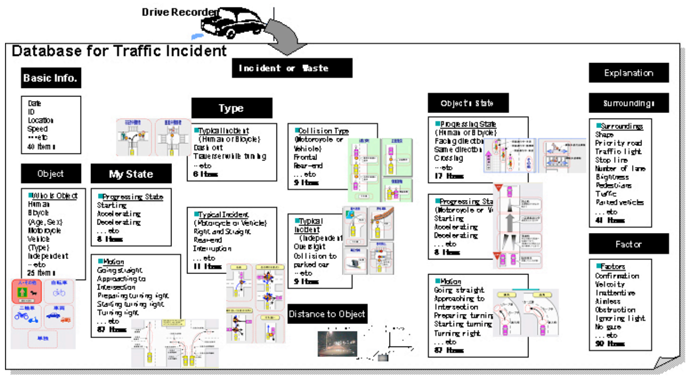

Figure 3 - Outline of database.

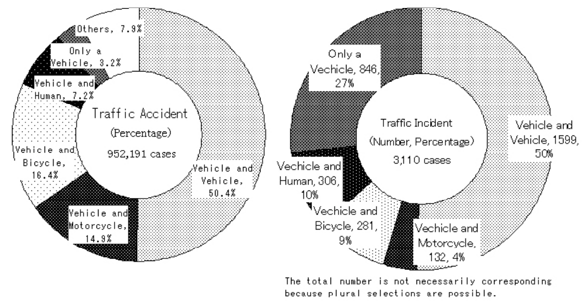

Figure 4 Comparison between traffic accidents (left) and traffic incident (right) on types.

between accidents and incidents in statistical characteristics. As an example, Figure 4 shows the comparison between traffic accidents and incidents. Left chart is the breakdown of traffic accidents in Japan in 2004 from statistics published by ITARDA, and right one is that of incidents collected by wide spread type drive recorders. From these charts, it can be seen that there exists correlation in the distribution of the traffic accidents and incidents. Hence, it could be said that the incident analysis gives useful information to discuss accident prevention.

4. PROPOSAL OF SCIENTIFIC APPROACH

The scientific approach to develop and evaluate the passive safety systems has been successfully constructed, while in the field of active safety systems, such approach has not yet been certainly determined, since the active safety systems involve not only the hardware but also the software systems concerning the field of human engineering, information and control[5]. It is important to use scientific approaches to the following research items: (1) accident analysis, (2) human factor study, (3) accident simulation, (4) sensing technology, (5) safety-related technology (such as ITS, ASV) and (6) effectiveness assessment.

5. CONCLUSIONS

In order to reduce traffic accident casualties, it is necessary to investigate the causes or primary factors that induce the occurrence of the accidents. For scientific approach to this problem, the effective and essential way is to detect and study not only accidents but also incidents by using drive recorder. JSAE activities related to incident collection and analysis with drive recorder are mentioned. Proposal of scientific approach related to active safety assessment making use of drive recorder and constructed database is also mentioned. As outlook of this field, the collaboration among each organization such as the cooperation of G.I.A. (Government / Industry / Academia) is strongly expected to settle the scientific approaches for halving or zeroing the road traffic accident casualties.

The author greatly appreciates to Prof. Masao Nagai, Prof. Minoru Kamata and Dr. Motoki Shino for their cooperation.

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Report on Completion of Commemorative Lecture and Ceremony for Establishment of “Machine Day and Machine Week”

Continued from page 1 about difficult problems on a global scale, such as the exhaustion of resources and climate change owing to mass production and mass consumption. The objectives of human society in the new century are to construct an enlarged human biosphere as a sustainable system that enables humans to coexist with the rest of the earth, and to ensure a healthy and comfortable life and a secure and safe society for people who each have different senses of value. In such a situation, JSME considers that it is essential to convince society that the development of machine-related technologies that are core elements of various technologies, as well as the creation of new values and the promotion of manufacturing, is required. With this background, JSME has set August 7th as “Machine Day” and the period from August 1st to 7th as “Machine Week” in cooperation with the various groups concerned. From the next fiscal year, many commemorative events will be planned and held during this week in collaboration with the various groups concerned. Using this occasion, JSME hopes to encourage young people in coming into science and technology world, and to support the nurturing of technical experts for the next generation, including women. Moreover, we intend to promote more international exchange of technologies in the academic field.

August 7th, Machine Day, is the day of the Festival of the Weaver, “Tanabata”, in Japan according to the traditional calendar, which is one month delayed compared with the solar calendar. “Tanabata” originated from “Kikkou-den”, which is a Chinese festival to pray for improvement in handicraft and needlecraft skills. It was introduced to Japan in the Nara Period (A.D. 710-784). It is said that the pronunciation of “Tanabata” came from the custom of weaving a sacred robe to be dedicated to God on that day, using a weaving machine called “tanabata”.

Commemorative Lecture

Masaki Shiratori (Yokohama National University), one of the vice-presidents of JSME, hosted the first section of this event, the commemorative lecture. First, in a lecture entitled “The History of Machines in Japan”, Kazuyoshi Suzuki (National Science Museum) introduced the history of machines, using many examples, as well as machine technology and background culture in Japan. In this lecture, Bow-Shooting Boy, which is a masterpiece created by Hisashige Tanaka, was demonstrated by the ninth Shobei Tamaya, who was involved with its restoration.

Next, in a lecture entitled “Mechanical Engineering as Thought”, Hiroyuki Yoshikawa (the President of Advanced Industrial Science and Technology) delved deeply into mechanical engineering from the viewpoint of history and philosophy, and also provided a lecture regarding future perspectives.

Commemorative Ceremony

Masato Tanaka (National Institution for Academic Degrees and University Evaluation), another vice-president of JSME, hosted the second section, the commemorative ceremony. Following a presentation on the background of the establishment of "Machine Day" by Shin Morishita (Yokohama National University), the administrative director, Nobuhide Kasagi (The University of Tokyo), the president of JSME, declared the establishment of "Machine Day" and "Machine Week".

After the declaration, the following guests gave congratulatory speeches: Tamotsu Tokunaga, the Chief of the Research Promotion Bureau at the Ministry of Education, Culture, Sports, Science and Technology; Shunichi Uchiyama, the Director-General for Manufacturing Industries Policy at the Ministry of Economy, Trade and Industry (on behalf of Tetsuhiro Hosono, the Director-General of the Manufacturing Industries Bureau at the Ministry of Economy, Trade and Industry); Yoshimasa Tamura, the head of the Technology and Safety Division of the Policy Bureau at the Ministry of Land, Infrastructure and Transport; Tsutomu Kanai, the president of The Japan Machinery Federation; and Hajime Sasaki, the president of The Japan Federation of Engineering Societies. Also, a congratulatory telegram from Kiyoshi Kurokawa, the president of the Science Council of Japan, and congratulatory messages from eight overseas mechanical engineering societies were presented.

Commemorative Celebration

After the ceremony, the participants moved to the Sanjo Conference Hall, where the commemorative celebration was held; approximately 130 guests attended. After the opening address by President Nobuhide Kasagi, Ayao Tsuge (a member of the Council for Science and Technology Policy) gave his congratulatory speech. Masao Takahara, the Director of the Society of Automotive Engineers of Japan (on behalf of Nobuo Okubo, the President of the Society of Automotive Engineers of Japan) also gave a congratulatory speech. The celebration started with a toast by the former president of JSME Hideo Ohashi (Kogakuin University), after which guests conversed informally with one another.

Future Vision

The total number of guests that attended the commemorative lecture and ceremony was approximately 250, and JSME hopes that they were able to understand the objectives of establishing the commemorative day. In the future, JSME will attempt to disseminate information to promote further understanding by the industries and academic societies concerned and, moreover, each office, such as the head, branch and division offices of JSME, plans to hold various events in many places in Japan, in collaboration and cooperation with other academic societies and associations, related companies, local governments, and educational institutions from the next fiscal year. JSME hopes to receive positive suggestions and proposals from each division, branch and member of JSME.
(Prepared by Shin Morishita, chief member of the Committee for the Establishment of Commemorative "Machine Day")

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