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STUDY ON DESIGNING AND INTRODUCTION OF A ROAD SAFETY MANAGEMENT SYSTEM AS A NEW ROAD SAFETY POLICY

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Abstract: Under the Japanese framework of road traffic safety policies, road administrators cooperate with traffic administrators to implement policies. But current guidelines and manuals do not fully address the needs of those in charge of implementing projects. The United Kingdom has instituted a road safety audit system under which teams of external experts perform safety assessments. This system is spreading to other countries. In Japan, road administrators are legally responsible for predicting and reducing road risks. It would be difficult for them to comply with the recommendations of external auditors, as the ultimate responsibility would be unclear. This paper studies a road safety audit system and its use. It also introduces a road safety audit system in which the road administrators themselves can audit road safety.

Key Words: Safety Policy, Road Safety Management System, Road Safety Audit, Auditor

1. INTRODUCTION

Under the Japanese framework of road traffic safety policies, road administrators, police departments and the local and central governments cooperate to implement traffic safety policies. The current guidelines and manuals do not fully address the needs of those in charge in the field to carry out traffic accident countermeasure projects. Insufficiency of safety references in road structure design standards is common to many countries. To solve this problem, the United Kingdom instituted the first a road safety audit system in the early 1990s. The major difference between this system and traditional safety policies is that a team of external experts perform safety assessments. This system has been deemed excellent and has spread to many other countries.

In Japan, in order to further reduce traffic fatalities, there is a call for the introduction of a new traffic safety policy similar to road safety audit. However, since external auditors' recommendations for design improvement are not legally binding, it would be difficult for road administrators to comply with such recommendations, as who was ultimately in charge would then become unclear.

This study aims to design and introduce a road traffic safety management system under which road administrators themselves can perform road traffic safety audits. In order to examine how to operate this system, we developed checklists for accident risk audit and check sheets for accident countermeasure selection, both of which constitute an integral part of the proposed system.

2. OUTLINE OF THE ROAD SAFETY AUDIT SYSTEM

The Road Safety Audit (RSA) System was first introduced in the United Kingdom in the early 1990s and then gradually spread internationally. It is a system whereby outside experts conduct safety assessment related to road construction.

In the U.K., Road Safety Audit is defined as "the evaluation of highway schemes during design, and before the scheme is opened to traffic, to identify any potential safety hazards which may affect any type of road user and to suggest measures to eliminate or mitigate those problems." This process was developed in the U.K. in the early 1980s as an Accident Investigation and Prevention (AIP) technique, when engineers noticed accident problems developing on relatively new roads.

In light of this, an initiative emerged for institutionalizing procedures as a more cost-effective way of securing road safety. In these procedures, safety assessment is done at an early stage of design and planning in a highway scheme, and improvement is required when any problem or risk factor is anticipated, because improvements, if any, are less cost effective once the highway has opened to traffic.

In *The Road Traffic Act of 1988*, Section 39 states that local authorities "in constructing new roads, must take such measures as appear to the authority to be appropriate to reduce the possibilities of accidents when the roads come into use." Section 39 of the *Act* was interpreted by road management organizations to mean that Road Safety Audit would help to satisfy this legal requirement.

In 1990, Road Safety Audit guidelines (namely the standards and the outline for implementation of RSA) were formulated. In the following year, RSA was formally institutionalized and became mandatory for all domestic motorway and trunk road schemes.

The RSA system established in the U.K. spread to New Zealand and Australia, and now it is used as a model in many countries for the formulation of guidelines and planning of some trunk roads. RSA has also become mandatory in planning national highways in Denmark. Many other countries have introduced the RSA system, or started feasibility studies including pilot programs. For example, Thailand, Malaysia, Singapore and South Africa already use RSA, and several states and provinces in the U.S. and Canada, Vietnam and China apply RSA to some of their highway schemes. In Northern European countries such as Finland and Sweden and in Western Europe, use of RSA is strongly supported and more and more countries are studying the applicability of the system (Figure 1)

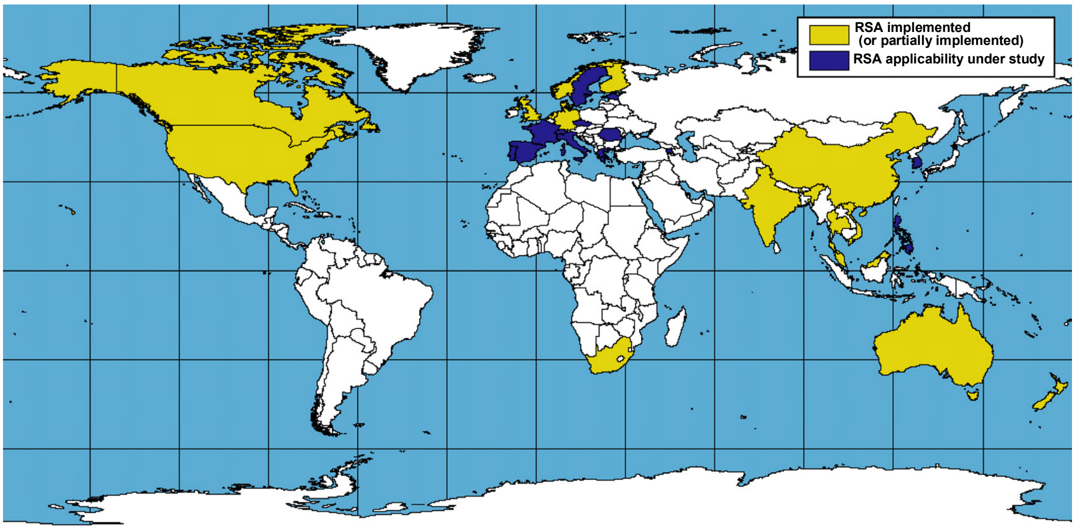

Figure 1. Countries Implementing RSA

3. RSA PROCESS

Regardless of the scale of scheme or the function of the planned highway, RSA in Australia is based on the four steps shown in Figure 2. A "step-by-step" approach is taken in each phase of implementation (Figure 3). For effective implementation of RSA, it is important to select appropriate auditors, acquire all relevant information, conduct effective field study, and prepare an audit report.

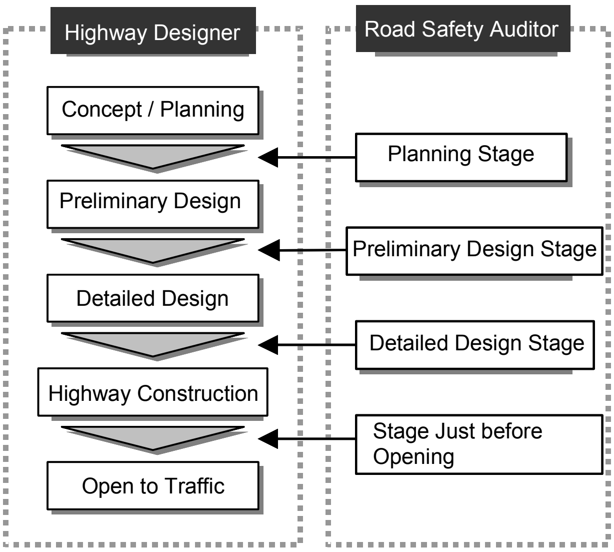

Figure 2. RSA Implementation Schedule (4 steps)

Auditors are basically required to have sufficient knowledge, skill and experience in road safety engineering, accident investigation and analysis, accident prevention work, traffic engineering and road planning. Although the qualifications in Figure 4 are proposed in Australia, they are not legal requirements but are under review toward establishment as national qualifications.

In many RSA procedures, a "checklist" is used. The list gives items to be checked with regard to accident probabilities in the road planning and design phases. The checklist is for examining the road scheme to determine whether the planned road is adequate for the expected traffic conditions. A purported advantage is that road designers can use the checklist before RSA is implemented to audit their engineering drawings themselves, thereby improving the road design safety. While the checklist used in the U.K. is relatively simple and allows for auditor discretion, that in Australia contains detailed descriptions.

Many of the countries using RSA make it mandatory to use a checklist at the stages of road planning and design for evaluation and preparation of a report. Thus, the checklist plays a crucial role for RSA. In the audit process, auditors use the checklist to evaluate documents such as designs and plans, and/or visits to the project site for field study (Figure 5)

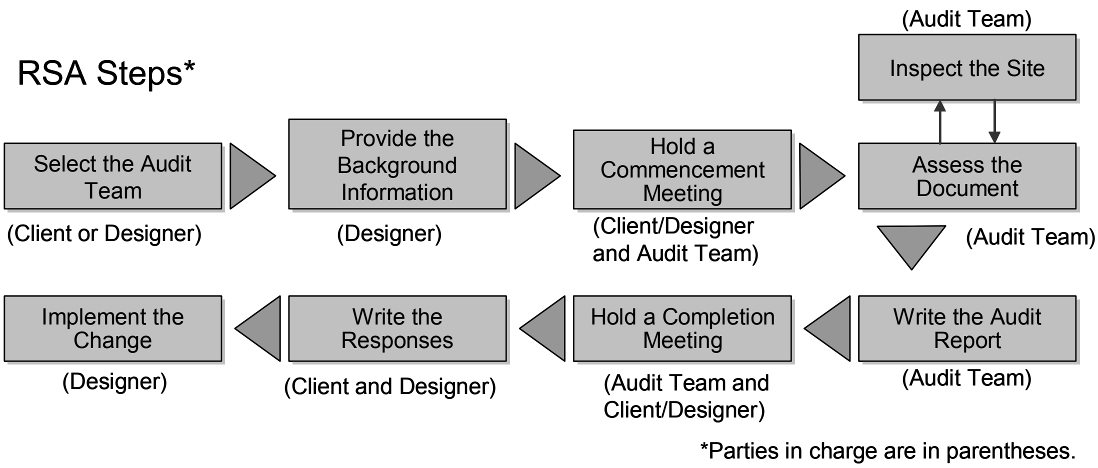

Figure 3. "Step-by-Step" Process of RSA

SOURCE: Austroads. *Road Safety Audit* (2002)

RSA Auditor Qualification Standards

Certified Auditor

•Completion of a certified RSA training course (two days or more).
•At least five years of experience in road design, road construction and traffic engineering (more years of experience are required for complicated schemes).
•As specified in the state Senior Certified Auditor Guidelines, experience of at least five RSA implementations. (At least three of these five times must be design stage RSAs.)
•Experience of RSA once or more annually (to maintain expertise).

Senior Certified Auditor

•At least five years of experience in road design, road construction, traffic engineering, and other fields related to road safety.
•Completion of an RSA training course certified by the state road authority.
•One or more RSAs annually (to maintain expertise).

Figure 4. Qualifications for RSA Auditors

SOURCE: Austroads. *Road Safety Audit Summit* (2001)

Figure 5. Field Study by the Audit Team

SOURCE: Austroads. *Road Safety Audit* (2002)

4. SAFETY MEASURES AND CHALLENGES IN JAPAN

Road administrators and police departments in Japan have been working together to implement traffic safety policies on the basis of long-term plans formulated in accordance with *The Emergency Measures Law for Traffic Safety Projects*. Figure 6 outlines the traffic safety measures, which are roughly divided into "securing safety by systematically developing trunk road networks," "emergency safety measures on existent roads," and "promoting accident investigations, analyses and studies."

Securing of Safety by Systematically Developing Trunk Road Networks

By systematically developing the trunk road network, it becomes possible to allocate a large part of automobile traffic to expressways and motorways in the network.
Expressways and motorways are designed to be safer than other types of roads in the network, thus, this measure improves safety of the entire trunk road network.
●Development of high-standard arterial highways, loop roads and bypasses.

Emergency Safety Measures on Existent Roads

Systematic promotion of traffic safety facilities
In cooperation with the Public Safety Commission, traffic safety facilities are systematically developed on accident-prone roads.
●Sidewalks, grade separation crossings, improved intersections and additional lanes
●Car parks, bicycle parks, road lighting, and road information services

Promotion of Accident Investigation, Analysis and Study

●Enhanced system of accident investigation and analysis that makes use of expertise
●Research and development of new traffic safety measures to prevent human errors, etc.

Figure 6. Traffic Safety Measures in Japan

While the Japanese government promotes road safety measures in its national strategy, it is difficult for local governments to take flexible measures that account for the specific road and weather conditions in cold snowy regions. There are very few traffic safety experts in road administration because Japanese universities do not offer education in road safety engineering as an independent field of study. Guidelines and manuals are not specific enough for those in charge in the field to implement traffic accident countermeasure projects. *The Ordinance on Road Structures* ensures the safety of each road component, but the safety of an entire road section design depends on the technical decisions of road designers.

Traffic fatalities in Japan have decreased from the record high 16,765 in 1970 to 7,702 in 2003, a drop achieved by the efforts of organizations concerned. Aiming at a further reduction in the number of fatal traffic accidents, in January 2003, Prime Minister Koizumi proposed that traffic fatalities be decreased to less than 5,000 in ten years, which would make Japan's road traffic environment the safest in the world. To realize a greater reduction in the fatalities, new traffic safety measures such as RSA are necessary.

5. EXAMINATION OF THE FEASIBILITY OF RSA IN JAPAN

In introducing RSA to Japan, the following need to be addressed:

- ✓ The need for public acknowledgement of the significance of RSA
- ✓ Procedures of RSA
  - Road and traffic schemes for applying RSA
  - Methodology
  - Auditing body
  - Use of time and expenses
  - Utilization of audit results
  - Legal status
- ✓ Qualification, training, and skill improvement of auditors, and designating or establishing a supervisory organization
- ✓ The necessity of several types of audit support databases and support software
- ✓ Post-audit follow-up
- ✓ Improvement and efficiency enhancement of the RSA process by means of various new tools

The biggest bottleneck in the introduction of RSA is expected to be audit by a third party. Currently, third parties that participate in the decision-making process of road traffic safety measures are local residents and organizations who present requests or suggestions to the road administration, but there is no legal basis to support such involvement.

Article 42 of *The Road Law* states that road administrators “shall maintain and repair roads such that they are kept in good condition, and shall make it a point to prevent general traffic from experiencing hindrances.” Article 2 of *The State Redress Law* stipulates that “When any defects in the construction or management of roads, rivers or other public structures have caused people to suffer damages, the national government or public organization(s) are liable for the damages.” Thus, regarding accidents caused by road structures or associated facilities, the legally responsible entities are explicitly stated.

Public demand for improved road management has been increasing. In the five years from 1997, there were 120 court-settled disputes related to road management defects, and 16,531 settled out of court. Compensation paid was 5.05 billion yen: 1.4 billion yen in court cases, and 3.65 billion yen in out-of-court settlements. Most of these actions related to differences in level and holes in the surface, but some cases arose from problems of road structures and flaws in safety facilities.

When three conditions are satisfied, the road administrator is responsible for accidents resulting from its failure to remedy road defects: a) the road has an accident risk, b) the risk is predictable by the road administrator, and c) the risk can be eliminated by the road administrator.

The fact that road administrators must assume responsibility for predictable and avoidable risks on roads suggests that auditors conducting RSA are also required to assume some responsibility. Auditors need to be qualified by a national examination, and the audit procedure should be standardized in a manual. It seems difficult for these requirements to be met anytime soon in Japan.

6. PROPOSAL FOR A ROAD SAFETY MANAGEMENT SYSTEM

The philosophy of RSA in auditing accident risks is expected to improve road safety, and traffic safety measures in Japan can adopt many things from it. In this regard, the audit process and the methodology of RSA were examined to develop an idea for a road safety management system by which road administrators can audit road safety.

First, by summarizing the characteristics and the roles of RSA in many countries, an RSA flow was examined for a new road scheme as well as for a risk countermeasures project of an existent road. RSA in other countries is usually applied to newly planned or designed roads, and its application to existent roads has started only recently. In Japan, accident countermeasures projects for accident-prone sections of existent roads are promoted, and thus it seems effective to apply RSA to these projects.

Two patterns of RSA flow are shown in Figure 7: "RSA of a newly planned / designed road," and "RSA of improvement work as accident countermeasures on an existent road."

We suggest the procedures for implementing safety audit as shown in Figure 8. They are the same as those of RSA in other countries up to the point where the incidences of accident risks assumed by a checklist are evaluated. To implement accident countermeasures, other steps were added, including planning of measures based on an accident countermeasures manual, assessment of impacts on the assumed road traffic environment, implementation of accident countermeasures, and assessment of post-measures effects. The Audit Office will be established in the road administrator's office to serve as an entity to conduct internal audit.

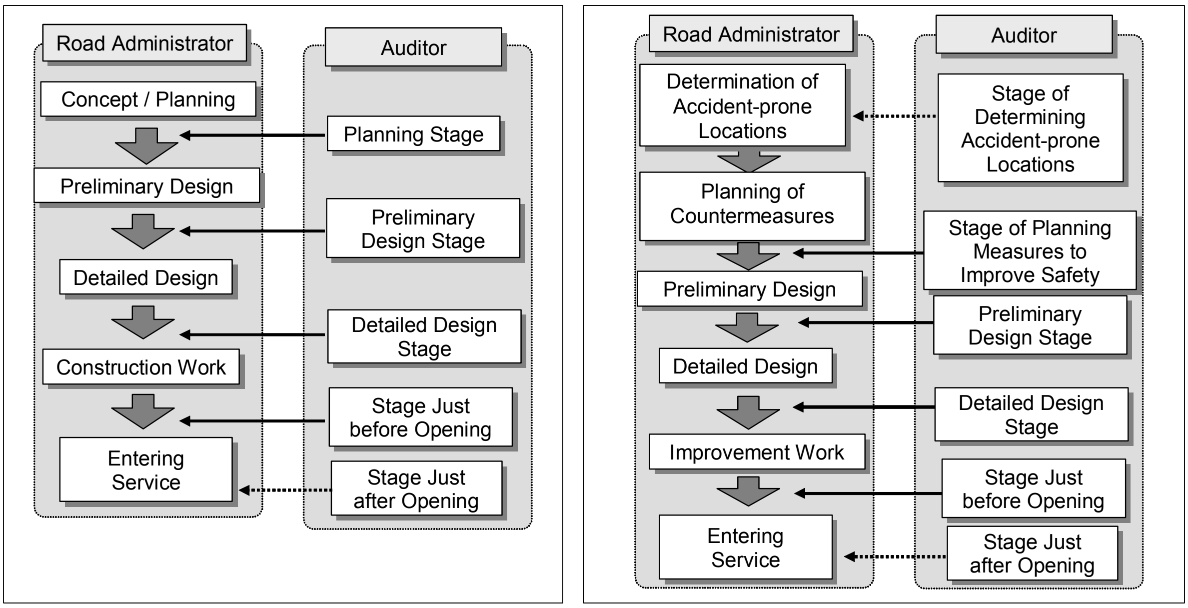

Figure 7. RSA Flow for a New Road (Left) and an Existent Road (Right) (draft)

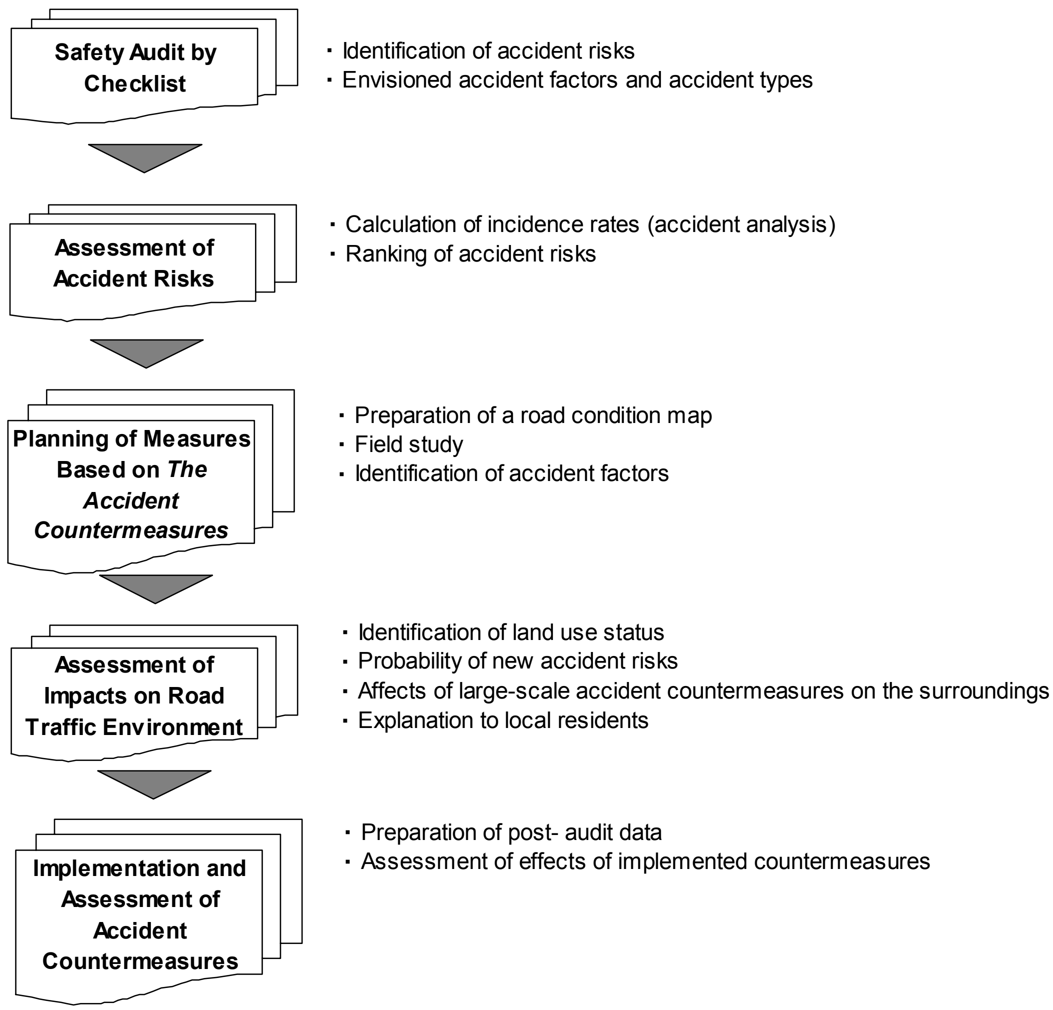

Figure 8. Audit of the Road Safety Management System

7. EXAMINATION OF THE CHECKLIST

The checklist and the traffic safety manual are particularly important to the audit process. They are examined here. The RSA checklist, which plays an important role in RSA and is used in many stages of the implementation process, was devised by road traffic organizations in the U.K., Australia and New Zealand, where RSA was first introduced. It is now utilized as a model checklist in the U.S., Canada and other countries that have introduced RSA or are studying introduction of the system.

The existing checklist was used in this study to create a new one that is better suited to Hokkaido, which has a cold snowy climate, widely dispersed cities, and a relatively low population density.

The checklist is used for ensuring that auditors check all the necessary items, rather than for evaluating each road scheme and project. First, a master checklist containing only the necessary items is prepared. Another type of checklist, the "detailed checklist," includes items and questions required for each particular road scheme or project. The items are divided into six stages covering both new roads and existent roads: I. Planning, II. Preliminary Design, III. Detailed Design, IV. Just before Opening, V. Just after Opening, VI. Existent Road. The questions at the planning stage are about the fundamental matters and nature of each project, and are about the process from designing to project implementation at the stage just before opening. The questions must cover a wide range to include all necessary general matters related to planning and project implementation.

Drawing upon the checklists used in Australia and New Zealand, and in Canada, another cold snowy region, nine basic checklist items for evaluating road environment safety were chosen. An item used to check road conditions peculiar to wintry Hokkaido was added to the nine basic items in the list (Figure 9). Table 2 shows an example of a detailed checklist suggested for the added winter condition check item.

Basic evaluation items

A. General (scope of project, interaction between new and existent facilities, etc.)
B. Road Structure (road classification, design speed and structure of cross-section, etc.)
C. Intersection (number and types of intersections, visibility, layout, traffic flow, etc.)
D. Road Surface (coefficient of sliding friction, pavement defects, surface condition, etc.)
E. Delineation Facilities (pavement markings, delineators, lighting, road signs, etc.)
F. Physical Objects (median strips, safety barriers/fences/shields, recovery zones, etc.)
G. Natural Environment (weather (short- & long-term), wild animals, etc.)
H. Road Users (automobile, pedestrian, bicycle traffic; etc.)
I. Access and Adjacent Development (access roads, development plans along the route, etc.)

Items specific to RSA for Hokkaido

J. Winter Conditions (road weather information, road maintenance operation, etc.)

Figure 9. Checklist

Table 2. Detailed Checklist for Cold Snowy Regions (example)

J. Winter Conditions			
No.	Audit Item	Implementation Stage	Points of Special Attention
J1 Road Structure			
J1.1	Design Speed / Posted Speed	I, II, III, IV, V, VI	Appropriateness of design speed in light of winter conditions Is it possible to place variable speed limit signs if required? (e.g., on road sections prone to changes in surface condition)
J1.2	Structure of Cross-Section	II, III, IV, V, VI	Adequate cross-sectional profile to satisfy basic demands of winter roads (sufficient space for traffic when snowbanks are formed at the Are drainage ditches free from clogging when there are snowdrifts? Is the slope sufficient to drain off snowmelt water (particularly at the road shoulder)? Does the slope design allow installation of anti-freezing facilities to cross-sectional slopes and curved sections? (i.e. cross-slope / normal crown)
J1.2	Road Alignment	II, III, IV, V, VI	Safety on the gradient in winter Are there curved points that are extremely prone to skidding when the surface freezes?
J1.3	Bridge Structure	II, III, IV, V, VI	Is it necessary to install signs for visual guidance and/or to warn of surface freezing? Are they What type of anti-freezing measures should be
J2 Intersections			
J2.1	Visibility/Sight line	III, IV, V, VI	Are the sight lines maintained even when snowbanks form?
J2.2	Traffic Control	III, IV, V, VI	Visibility and reflectivity of markings during snowstorm

8. EXAMINATION OF *THE ACCIDENT COUNTERMEASURES MANUAL*

So that measures against traffic accidents may be taken, technical information should be accumulated for accurate implementation of every necessary step. Currently, relevant information is found in many different places, and there is no well-organized manual. Thus, in this study, an accident countermeasures manual that includes audit items on the checklist was examined so that precise action can be assured.

In this manual, a list (called a check sheet) of as many effective accident countermeasures as possible was included, so that they could be easily selected by the persons in charge. For this list, accident patterns were identified according to information on places with accident risks and risk factors. There are six kinds of check sheets for different accidents: head-on collision, rear-end collision, right-angle collision, collision with structures or run-off-the-road, collision with pedestrian, and "winter-type" accident, which is peculiar to Hokkaido. Each sheet describes accident factors, details of the factors, critical points of field observation, and the corresponding countermeasures. We examined periods and costs for introducing each accident countermeasure and summarized the results in a table. Table 3 and Table 4 are examples of a list and a check sheet respectively. Each accident countermeasure is briefly summarized, including its advantages and effects, and its problems.

Table 3. List of Road Safety Measures (example)

H : highly applicable A : applicable blank: not applicable

		Time & cost assessment code	Countermeasure	Accident type						Period required for introduction			Cost for introduction and management			
				Head-on collision	Rear-end collision	Right-angle collision	Collision with structures or run-off-the-road	Pedestrian/bicyclist injuries	"Winter-type" accident	Short, within 1 year	Medium, 1 ~ 2 years	Long, more than 2 years	Low	Medium	Fairly high	High
										I	II	III	A	B	C	D
Carriageway	Alignment improvement	III-D	Improving horizontal alignment (radius of curve modification, widening of curve section, sight distance improvement)	H	A	A	H	A	H			●				●
		III-D	Improving vertical alignment (gradient modification, combination with a curve, sight distance improvement)	H	H	A	H	A	H			●				●
		II-C	Improving cross-slope (slope modification, improvement of superelavation)	H	A	H	H	A	H		●				●	
		II-C	Improving alignment at the influx of an intersection (horizontal alignment, vertical alignment, angle of intersection)	A	H	H	A	H	H		●				●	
	Improvement of road width and cross section	II-B	Lane widening	H	H	H	H	A	H		●			●		
		II-B	Shoulder widening	H	H	H	H	A	H		●			●		
		II-C	Adding a crawler lane / lane for yielding vehicles	H	H	A			A		●				●	
		II-C	Building a 2 + 1 carriageway (adding a passing lane)	H	H	A			A		●				●	
			[illegible]													

As an example, Figure 10 shows a measure against head-on collisions (rumble strips). Persons in charge identify accident risk factors on the checklist, and select appropriate countermeasures from those described on the list of road safety measures as well as the check sheet.

Table 4. Check Sheet for Head-on Collisions (example)

Accident type		Factors	Details	Note in advance	Field observation point	Record at field inspection	Countermeasure	Remarks
Head-on collision	Geometric design	Passing in a section of poor visibility	Difficulty of seeing oncoming Difficulty of seeing road		Horizontal/ vertical alignment, sight Combination of curves and vertical alignment (curved sections, crests)		Improvement of sight distance Improving horizontal alignment Improving vertical alignment Placing delineators, enhancing visibility (light-emitting delineator, increasing luminance) Placing statutory/non-statutory caution signs, enhancing visibility (by enlarging signs, increasing luminance, and adding light-emitting delineator) Placing road markings and increasing their luminance of (letters, marks, arrows) Introducing a system to display the approach of vehicles on the opposing lanes	Investigation (visual guidance, lighting)
			Hard to see or identify the centerline		Worn-out road markings		Installing a centerline (median strip, narrow median strip, low-cost center strip, marking) Installing a centerline, enhancing visibility (enhancing luminance, installing chatter bars, or light-emitting Installing rumble strips at the centerline	
		Alignment and profile of carriageway	Driving improperly or in the oncoming lane on a long straight section ・Speeding ・Reckless ・Inattentive driving, including sleepiness		Traveling speed Traffic flow Surface condition / Skid marks Use of road signs		Improving plane alignment (adding a circular curve) Placing statutory / non-statutory caution signs, enhancing visibility (by enlarging signs, enhancing luminance or adding light-emitting delineators) Controlling speed and attracting attention by pavement (anti-skidding pavement, grooved Installing a centerline (median strip, narrow median strip, low-cost median strip, center fences) Installing rumble strips at the centerline Preparing rest facilities and car parks	
			Narrow road width (carriageway and shoulder)		Lateral distance to vehicles in the Shoulder width Roadside conditions		Widening the carriageway Marking off a narrow central zone Improving a 2-lane into 3-lane (adding a passing Building an alternating passing lane or a four-lane carriageway in a critical section	

Rumble Strips

[Outline]

・The pavement is incised or made bumpy, so that vehicles deviating onto the strip are alerted by noise and vibration. When placed at the centerline, head-on collisions are prevented.

[Advantages / Effects]

・Head-on collisions caused by driver inattention or sleepiness can be reduced in suburban areas, where such accidents are frequent.

・Rumble strips installation has a low cost and the strips do not disturb traveling, making them ideal for long straight two-lane sections.

・For motorcycles and bicycles, rumble strips are safer to run on than traffic buttons and center posts.

・Rumble strips are not damaged by snow removal, making them ideal in terms of maintenance.

[Problem]

・Rumble strips cannot prevent vehicles from deviating when they skid and lose control.

Figure 10. Accident Countermeasures (Head-on Collision: Rumble Strips)

9. CASE STUDY ON SAFETY AUDIT

A case study was done on National Highways 231 and 453 on use of the checklist and the check sheet. On Route 231, a section near downtown Sapporo was studied. The section has many structures such as bridges including those for grade separation, and the road structure greatly varies within the section. On Route 453, a section in a suburban area was chosen because it has many guard fences, retaining walls and similar structures, and its alignment has great variation, including many curves and slopes.

Before conducting field observation, drawings of these road sections that show the present state of the sections were collected, and accident data and accident condition maps were obtained from the Traffic Accident Analysis System. Based on these data and the checklist, factors and risks of accidents were theoretically analyzed. Field study was done as shown in Figure 11. The accident types were identified first, and the corresponding check sheets were used to specify accident factors and countermeasures.

Some of the accident risk factors identified in this process are as follows:
[Route 231]
- The crash cushions at the edge of the retaining wall may not be effective enough, depending on the collision angle.
- Planting on the slope of a large embankment on the roadside is not dense enough, and measures are necessary to prevent pedestrians from tumbling down.

[Route 453]
- Utility poles at the curved section are very close to the carriageway.
- The shoulder is narrow and different in level from the carriageway.
- The retaining wall is close to the carriageway, with no collision-prevention measures at the end.

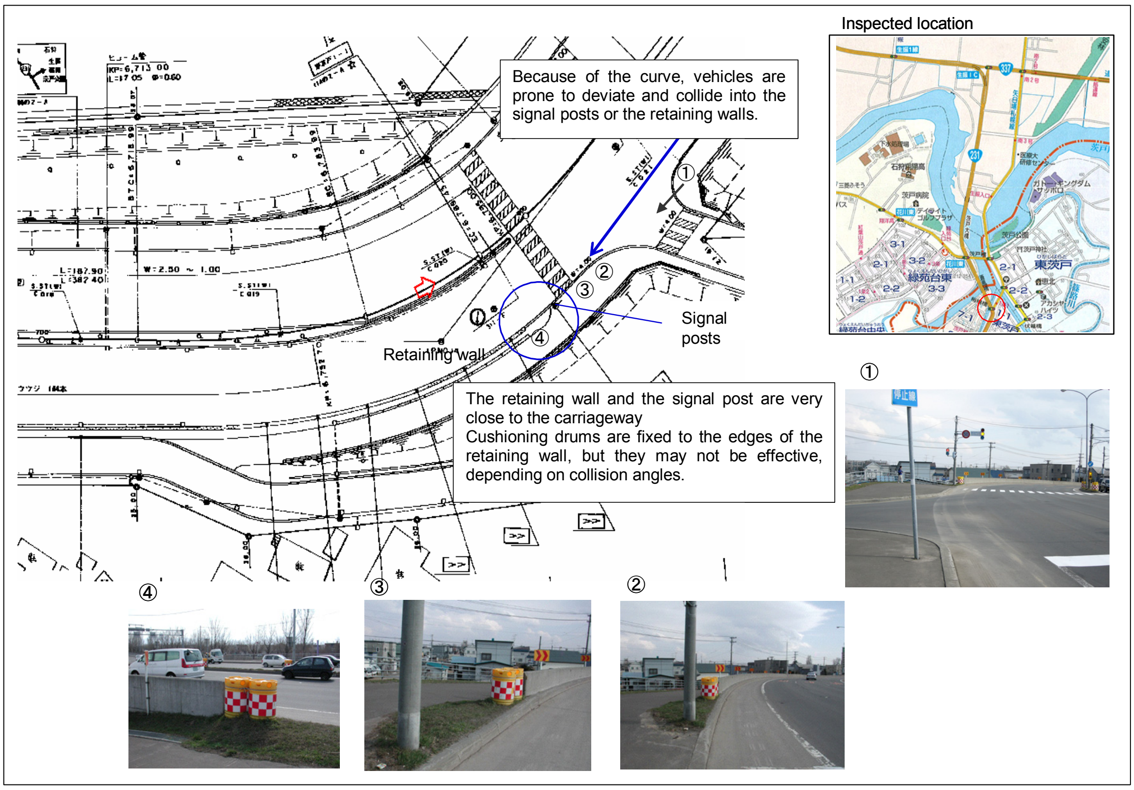

Figure 11. Results of Safety Audit on Route 231

With regard to these accident risk factors, some countermeasures were proposed, namely placement of shock absorbers, guard railings, guard fences and delineators, modification of horizontal and vertical alignments, and widening and level-modification of the shoulder.

10. CHALLENGES FOR THE FUTURE

The issues to be addressed for the Road Safety Management System include:

- Its role in road administration
- Auditor training programs and the function of the Audit Office
- The validity of checklists for safety audit
- Assessment methods of identified accident risks
- Adequacy of *The Accident Countermeasures Manual*
- Effectiveness assessment of selected countermeasures
- Assessment methods of selected countermeasures in terms of budget, immediacy and priority
- Implementation of field tests of road safety audit

11. CONCLUSION

The Road Safety Audit is a system of new road policies that is already used or under feasibility study in many countries. In introducing it to Japan, the biggest bottleneck seems to be the requirement that the audit be by a third party. However, RSA is sure to be effective in improving road safety and reducing accidents because safety is audited at the planning stage of new road schemes as well as for existent roads.

In light of this, the study proposes the Road Safety Management System as an internal safety audit system. Many issues need to be addressed regarding this system, including the establishment of an independent Audit Office, audit processes, and assessment methods of accident countermeasures. Because the checklists and the accident countermeasures manual are important for the Road Safety Audit system and they are expected to be useful for the current road administration, study will be continued chiefly for the purpose of improving them.

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