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A STUDY FOR HAZARDOUS ROAD SELECTION CRITERIA FOR PROVINCIAL ROADS

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Abstract: The traffic safety improvement projects must consider accidents as well as synthetic methods including road and traffic characteristics. But current executing in domestic selects a spot or section chosen by the number of accidents for improvement. For solving this problem, this study analyzes the provincial roads' accidents during 2000~2002 year, and the characteristics of provincial roads have been investigated and the influencing factors to hazardous road based on previous studies are identified. Factors are regarded the priorities by AHP and awarded points to easily apply in real world situation.

Key Words : Traffic safety improvement project, Hazardous road, Provincial road, AHP

1. INTRODUCTION

1.1 Background and Objective

The current traffic safety improvement projects carrying out in Korea are mainly consisting of black spot, hazardous road and bottle neck improving project. These projects are not implemented on a systematic and integrated appraisal method but simply select a spot or section chosen by the number of traffic accidents for those. The method relying on the number of traffic accidents could miss the possible accident causation by typical road condition and various traffic characteristics. Even though the traffic accident didn't occur on a certain road during past few years, still it is possible to occur on that road in the near future. This phenomenon can be explained by the unique characteristic of traffic accidents. To maximize traffic safety improvement project, it is better to select hazardous roads considering road and traffic characteristics. Solving this problem, this study introduces the criteria of selecting hazardous roads. In order to develop the criteria, the related data of 348 provincial roads(total 20,740Km as of December 31, 2002) and accident data(years of 2000 ~ 2002 : 3years) in Korea are collected.

1.2 Method

The first step was getting a grip of the accident features of the region through the analysis on general status and accidents. Elements for the standards of selecting hazardous roads were collected through investigating documents from in and out of the country. Then through AHP Method, relative importance of collected elements was calculated. Based on the standards selected through this process, we have prepared the hazardous road selection criteria and scoring method. Detailed research flow chart is shown in Figure 1.

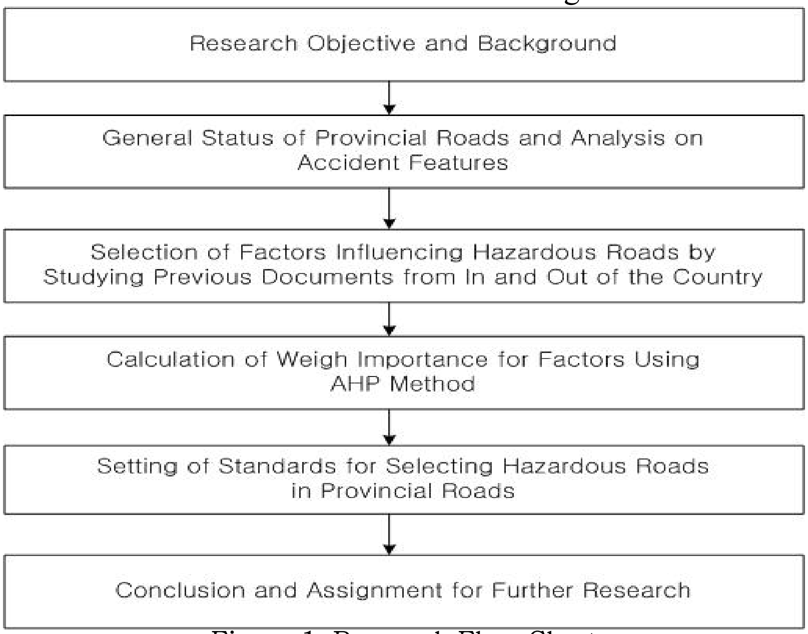

Figure 1. Research Flow Chart

2. INVESTIGATION ON PROVINCIAL ROADS STATUS AND ACCIDENT FEATURES

2.1 Investigation on Provincial Roads Status

Provincial roads refer to the road within a region of self-governing body of province that is acknowledged by the corresponding mayors[1] and are categorized into either General Provincial Road or Nationally Supported Provincial Road[2]. Provincial roads as of December 31, 2002 are 348 lines expanding 20,740km and average pavement rate is 78.9%.

Table 1. Provincial Roads Status for Cities (as of December 31, 2002) – unit : m

	Provincial Road (Nationally Supported Provincial Road)				
	Length	Pavement	Pavement Rate : %	Non-pavement	Closed to Traffic
Total	17,083,514	13,329,628	78.0	2,441,769	1,312,117
	(3,656,550)	(2,919,483)	(79.8)	(312,731)	(424,336)
Pusan	73,640	54,900	(74.6)	18,740	-
	(73,640)	(54,900)	(74.6)	(18,740)	-
Daegu	17,597	17,597	100	-	-
	(17,597)	(17,597)	(100)	-	-
Inchon	65,740	43,920	66.8	-	21,820
	(65,740)	(43,920)	(66.8)	-	(21,820)

1 Road Law (Ministry of Construction and Transportation)

2 Connection of major transportation area including major cities in provinces, air ports, harbors, industrial complex, major facilities, touring sites and etc, with lines supporting national nucleus road network composed of assigned highways

Ulsan	12,900 (12,900)	12,900 (12,900)	100.0 (100)	- -	- -
Gyeonggi-Do	2,522,846 (991,486)	1,947,316 (775,296)	77.2 (78.2)	281,870 (81,400)	293,660 (134,790)
Gangwon-Do	1,498,341 (225,678)	1,231,431 (218,078)	82.2 (96.6)	243,310 (5,600)	23,600 (2,000)
Chungcheongbuk-Do	1,460,225 (268,325)	1,304,915 (238,115)	89.4 (88.7)	118,500 -	36,810 (30,210)
Chungcheongnam-Do	1,817,400 (370,900)	1,365,000 (260,500)	75.1 (70.2)	343,700 (32,000)	108,700 (78,400)
Jeollabuk-Do	1,688,890 (266,427)	1,352,560 (257,327)	80.1 (96.6)	237,280 (4,500)	99,050 (4,600)
Jeollanam-Do	2,293,400 (333,800)	1,572,550 (226,250)	68.6 (67.8)	460,050 (27,850)	260,800 (79,700)
Gyeonsangbuk-Do	3,012,420 (676,120)	2,421,364 (550,721)	80.4 (81.5)	475,276 (98,909)	115,780 (26,490)
Gyeonsangnam-Do	2,320,515 (318,537)	1,781,175 (228,479)	76.8 (71.7)	263,043 (43,732)	276,297 (46,326)
Jeju-Do	299,600 (35,400)	224,000 (35,400)	74.8 (100)	- -	75,600 -

Note) ( ) included in "provincial roads" as "Line Supported by the Nation”

2.2 Analysis on Accidents in Provincial Roads

Among the accident data provided by the Police Agency, only the data happening on the provincial roads(years of 2000 ~ 2002) were collected to analyze the features of provincial accidents. Analyzed accident features are used as variables for hazardous road selection criteria along with collected geometrical features and environmental factors through the literature study.

2.2.1 Daily Accident Features

According to the number of accidents occurring in a day in provincial roads, we can observe that a number of accidents are greater in weekends compared to other weekdays. It is suggested that increasing traffic volume of a weekend excursion is caused.(Figure 2)

2.2.2 Accident Features According to Geometrical Structures of a Road

As a result of comparing the number of accidents(accident rate) to the overall number of accidents in provincial roads with width of the road, it was proven the accidents occur most frequently in roads having less than 3~6m and 6~9m width. It shows that when the width of the road is narrow, the alignment and safety facilities are relatively inappropriate.(Figure3)

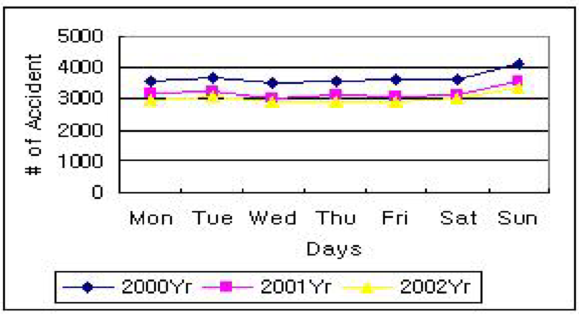

Figure 2. Number of Daily Accidents in provincial roads

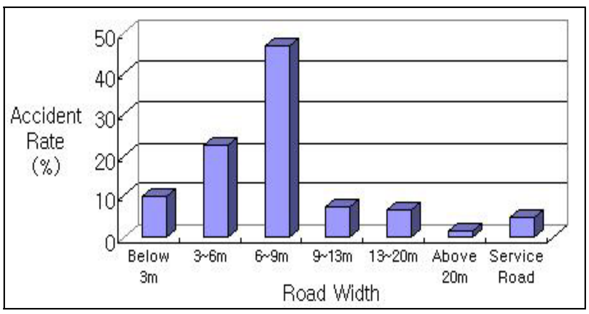

Figure 3. Ratio of Accidents Occurring according to Road Width(Below 3m road is one-lane road)

In terms of the accident rate according to the road type and formation, both the intersection and one-way road had high accident rate in a straight section with long expansion length. However, the death rate compared to accident case was relatively higher in the curve section, proving that curve section has higher risk than straight section.

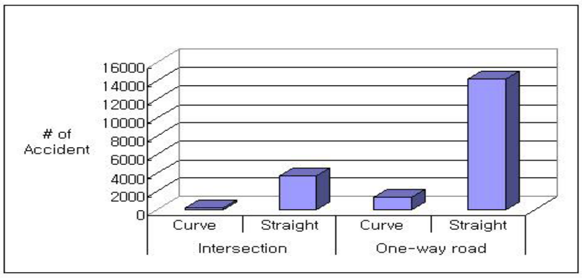

Figure 4. Number of Accidents According to Road Types and Formations

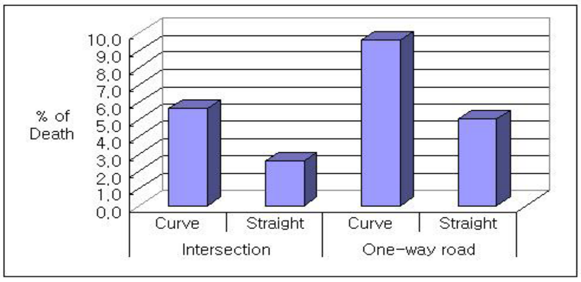

Figure 5. Death Rate According to Road Types and Formations

Searching for the accident types according to the road alignment in the intersection, both the curve and straight section has highest number of vehicle/vehicle accidents. Also, compared to straight area, curve section has more vehicle/vehicle accidents, which is probably the result of over speed and inaccurate alignment.

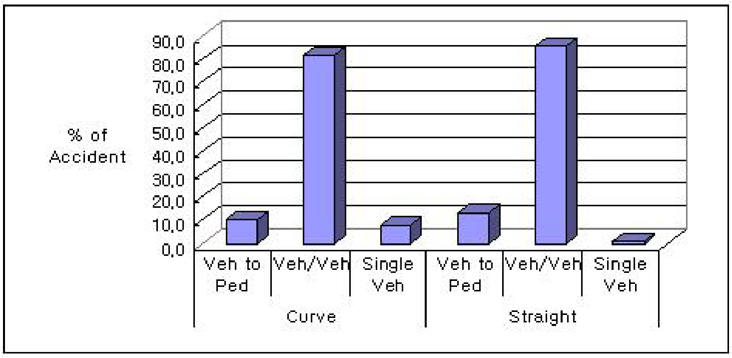

Figure 6. Rate of Accidents According to Intersection Forms and Accident Types

2.2.3 Accident Features According to Accident Types

In terms of the accident features of vehicle to pedestrian, vehicle/vehicle and single vehicle accidents, the order of accident types is vehicle/vehicle, vehicle to pedestrian and single vehicle accidents. However, the death rate compared to accident cases is in the order of vehicle to pedestrian, vehicle/vehicle and single vehicle accident, proving how the walking environment in provincial roads is in serious condition.

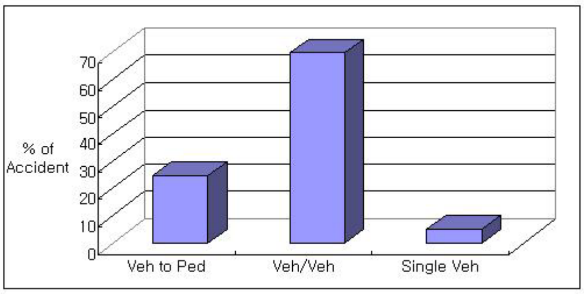

Figure 7. Rate of Accidents According to Accident Types in Provincial Roads

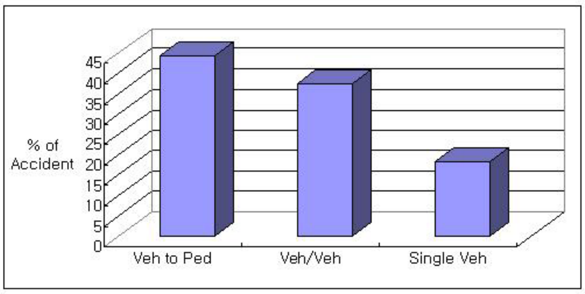

Figure 8. Death Rate of Accident Types in Provincial Roads

2.3 Results of Analysis

Accident and road features of provincial roads through the analysis are as shown below.

- Provincial roads have more accidents during the weekends than other days.
- The ratio of accident occurring in the width of the road ranks highest both in a width less than 3~6m and 6~9m.
- Provincial roads have higher death rate in curve section compared to straight rate and higher rate of single vehicle accidents.
- The order of death rate compared to the number of accidents in provincial road was proven to be in the order of vehicle to pedestrian, vehicle/vehicle and single vehicle accident.

3. CASE AND LITERATURE REVIEW

3.1 Investigation on Foreign Cases

3.1.1 Australia (Road Safety Black Spot Program)

In case of Australia, this program has been promoted for only 3 years since 1990. Then it was re-induced in 1996 and reformed for 2,100 spots having the most frequent accidents all the area of Australia has been performed. Australian standards for selecting area(spot or section) with frequent accidents are mentioned as follows.

Spot Accident Standards : In a unit of federal government, the spot with more than the number of 3 accidents caused by human in a certain year on state or provincial roads becomes the standard. In case of state unit, the spot with one or more accidents with related to the human in 5 years on provincial roads becomes the criterion.
Road Section Accident Standards (Section of longer than 3km) : In a unit of federal government, upper 10% point on the road with highest accident rate among the states or provincial roads becomes the standard. In case of state unit, an area with average of 2 or more accidents(human + physical) within 5 years per km in provincial roads becomes the standard. The data for accidents is used in recent 5 years.
Road Safety Assessment Proposal : Even if the point of area that does not fulfill the accident occurrence standard stated above can be improved up to 20% of the improvement program when the point has potential for the risk based on the official “Road Safety Assessment Report” report.

3.1.2 Japan

National Police Agency and Ministry of Construction of Japan has been promoting "Urgent Countermeasure Project for Frequent Car Accident Region", which focuses on the reduction of accidents such as intersection reformation, installation of street lights, re-inspection of traffic regulation and etc since 1996. Region selection standards are as follows.
General Rule : A region for reformation includes the point where one or more accidents are most likely to occur in 10 years and a point with more than one indices among three index of death accidents, death and injury accidents and potential death accidents.
Selection Standards : Regions with more than two cases of car accidents causing death or injury within 4 years are subjected to reformation. And regions with more than 0.4 cases of life taking accidents converted according to the accident types such as front collision, rear collision and etc, are subjected to reformation.

3.2 Suggestion Point

Both Australia and Japan select roads with frequent accidents based on the accident frequency and severities. In the case of Australia, the reformation business for each spot and section is performed whereas Japan doing only the former. Australia considers dangerous geometrical structures and environmental elements by reflecting the potential risk of the roads and Japan reflects the risk of roads through potential death accidents which are not revealed by actual accidents.

3.3 Literature Review

3.3.1 Point Accident Standards

- Critical Accident Rate Method : This method analyzes whether a section of a roads has relatively higher accident rate than the average through the statistical method. Statistical analysis is performed under the hypothesis that the occurrence of general accidents follows Poisson Distribution.

$$R_c = R_a \pm K \times \sqrt{\frac{R_a}{M}} \pm \frac{1}{2M} \qquad \text{Equation 1}$$

where, R_c : Critical rate(# of accidents/10^8km), R_a : Average rate(# of accidents/10^8km)
K : Confidence level M : Exposure(=(ADT x 365 x segment length x years)/10^8)

- Property Damage Conversion Method : This method is the method that reveals one unit of damage through converting such damage types as death, injury and property damage into equal value. Case of death and injury accidents is divided by an average damage cost of a property damage to obtain severity factor of injury, death and property accident. It is generally decided based on the national economic loss according to the type of accident.

$$Severity \quad Index = \sum_{i=1} P_i n_i \qquad \text{Equation 2}$$

where, P_i : accident number per accident types, n_i : Severity factor of accident types,
i : Accident type(fatal, injury, property, etc)

3.3.2 Regression Method

- D. Solomon(1964) had tried to analyze the relationship between horizontal curve and accidents. He used Weighted Least-Squares Procedure in structuring a model predicting the accident to perform multiple linear regression analysis.

$$Y = AR_s(L_c + L_t)(V) + 0.0336(D)(V) \qquad \text{for } L_t \geq L_c \quad \text{Equation 3}$$

where, Y : # of accidents, AR_s : Accident rate of straight section,
Lc : Length of curve section(mile), Lt : Length of straight section(mile),
D : Degree of curvature, V : Volume(ADT)

- C. V. Zegeer et al(1991) had developed D. Solomon(1964)'s model to analyze the causes of accidents more accurately.

$$Y = \{1.552(L \times V) + 0.14(D \times V) - 0.12(S \times V)\}(0.978)^{(w-30)} \quad \text{Equation 4}$$

where, Y : # of total accidents on curve section, L : Length of curve(mile),
S : Being transition curve=1, Not being=0, V : Volume(ADT), W : Lane width(ft)

- C. V. Zegeer et al(1986) had selected the final variables to be used in the models by performing stepwise regression and ANOVA on the variables believed to influence the accident. And by performing non-linear regression analysis using the final variables, he developed accident prediction model for provincial roads with two lanes.

$$Y = 0.0019(ADT)^{0.8824}(0.8786)^{w}(0.9192)^{PA}(0.9316)^{UP}(1.2365)^{H}(0.8822)^{TER1}(1.3221)^{TER2} \quad \text{Equation 5}$$

where, Y : # of total accidents, W : Land width(ft), PA : Pavement shoulder width(ft),
UP : Non-paved shoulder width(ft), H : Median roadside hazard rating,
TER1 : Flat=1, non=0, TER2 : Mountain=1, non=0

- Choi, Jae Sung et al(1995) had performed multiple regression analysis in three types of straight line, negative-exponential and root square equation to derive accident rate prediction model and selected the root square equation with the most excellent test result of a model with coefficient of determination (R^2), F-value, t-value and residual analysis result.

$$\begin{aligned} Y &= a_1 W + a_2 R \\ Y &= a_1 \exp^{-W} + a_2 \exp^{-R} \\ Y &= a_1 W^2 + a_2 R^2 \end{aligned} \quad \text{Equation 6}$$

where, W : Lane width(m), R : Radius(m)/1,000

3.4 Collection of Factors Influencing the Selection of Hazardous Roads

According to the past research, the major factors that influence the selection of hazardous road include traffic volume, width of the road and shoulder, horizontal curve and pavement ratio. Items mentioned above have been reflected in the process of selecting hazardous roads in this research.

4. DETERMINATION OF FACTORS INFLUENCING ACCIDENTS AND COMPUTATION OF RELATIVE IMPORTANCE AMONG FACTORS

4.1 AHP Method

AHP method proposed by Professor Thomas L. Satty of U.S.A provides the optimal selection among many options in modern society that is becoming more complex and diverse. The assessment is performed by reflecting the professional opinion based on the rational process of decision making. This is one of the many measuring and logical decision making methods that reflect general human’s behavior and analytical thought process. It is not only easy to apply but also widely used in decision making process of public and official areas because of its accurate theoretical evidence. This procedure is shown below.

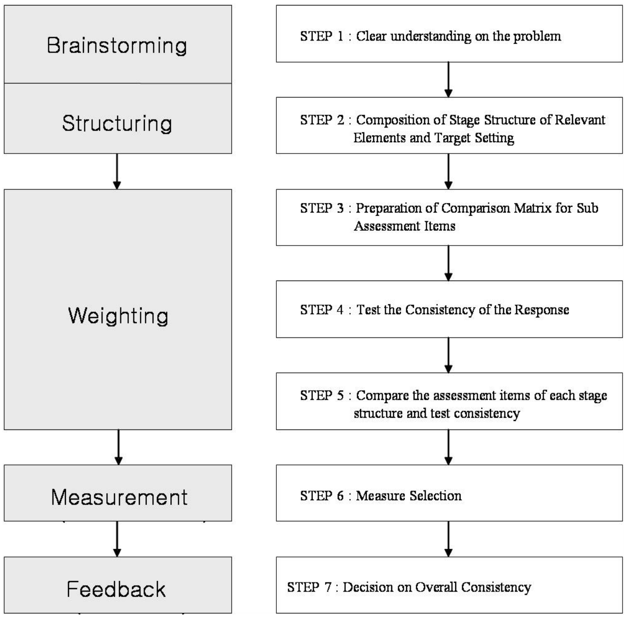

Figure 9. AHP Method Procedure

4.2 Result of Performing AHP Method

In this research, prior to performing AHP method, a survey was conducted on 26 traffic specialists serving in transportation industry or research areas for the hazardous road selection standards through the investigation on provincial road accident features and document study. To integrate the assessment value of 26 responders, Figure Integration Method[3] generally used in group decision making process of AHP has been used to calculate the level of importance. In addition to the former method that only considers the number of accidents, local government opinions, which is believed to have good ideas of geometric features in their own area, traffic characteristics and regional conditions were also considered. As a result of performing AHP method, the importance level of accident severity, geometric features, traffic characteristics and opinions of local government had been calculated. Following is the result of using Figure Integration Method.

Table 2. 1:1 Comparison Table for Overall Evaluator using Figure Integration Method

	Accident Severity	Government Opinions	Traffic Characteristics	Geometric Features
Accident Severity	1	5	4	3
Government Opinions	0.2	1	0.333333	0.25
Traffic Characteristics	0.25	3	1	0.333333
Geometric Features	0.333333	4	3	1

Geometric Mean and Importance Level about accident severity can be computed as below.

- Geometric Mean = (1 x 5 x 4 x 3)$^{(1/4)}$ = 2.78
- Importance Level = 2.78 / 5.26 = 0.53

[3] A method of integrating the means of overall evaluators about each elements of Paired Method

Table 3. Result of Calculating the Importance Level of Evaluators

	Accident Severity	Government Opinions	Traffic Characteristics	Geometric Features	Geometric Mean	Weight
Accident Severity	1	5	4	3	2.78	0.53
Government Opinions	0.2	1	0.333333	0.25	0.36	0.07
Traffic Characteristics	0.25	3	1	0.333333	0.71	0.12
Geometric Features	0.333333	4	3	1	1.41	0.28
Sum(S_j)	-	-	-	-	5.26	1

Results of calculating the importance level were Accident Severity Standard (0.53), Government Opinions and related organs (0.07), Traffic Characteristics standard (0.12) and Geometric Features standard (0.28). When these scores are converted to 100 point scale, results are shown as below.

- Accident Severity Standards : 50 points
- Geometric Features and Traffic Characteristics Standards : 40 points
  (Geometric Features Standards : 28 points, Traffic Characteristics Standards : 12 points)
- Government Opinions : 10 points

To test AHP result, the importance levels were multiplied by each column of judgment standards in 1:1 comparison table. The driven figures are summarized in Table 4. Then the sum of each column was divided into the importance level of each assessment standards.

Table 4. Result of Calculating Constancy Index of Evaluators

	Accident Severity	Government Opinions	Traffic Characteristics	Geometric Features	Row Sum	Row Sum/Weight
Accident Severity	0.53	0.34	0.54	0.81	2.21	4.19
Government Opinions	0.11	0.07	0.04	0.07	0.29	4.19
Traffic Characteristics	0.13	0.20	0.13	0.09	0.56	4.18
Geometric Features	0.18	0.27	0.40	0.27	1.12	4.17
Sum(S_j)	-	-	-	-	-	16.72

After computing the means of values obtained from Table 4, consistency index had been calculated.

- Means = 16.72 / 4 = 4.18
- CI(Conformity) = (Means-Number of Items) / (Number of Items-1) = 0.060
- CR(Consistency Index) = CI(Conformity)/RI(Random Index[4]) = 0.07

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[4] Random Index can be obtained from the table below according to the number of factors (n).

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

As the result of calculating consistency index, its value is 0.07, when it is less than 0.1, it is judged that the process of decision making is consistent. According to the AHP method, the importance level of Traffic Characteristics element was in the order of traffic volume and ratio of heavy vehicles. In terms of Geometric Features, the order was found to be sight distance, horizontal curve, lane width, shoulder width, crosswalk and pavement ratio. The driven results were recalculated in the scale of 100 points and Chapter 5 explains in detail.

5. SETTING OF SELECTION STANDARD FOR HAZARDOUS ROAD IN PROVINCIAL ROADS

The scoring for each assessment item is to be calculated in a method that can be applied realistically and maintained objectivity. In order to do so, we have chosen a method that can apply equations or methods that are able to represent assessment items or through ranking order. The Importance Level of assessment items calculated through AHP method can be summarized as shown below in a scale of 100 points.

Table 5. Scoring of Assessment Items

Assessment Items			Score(Point)
Accident Severity(50%)			50
Geometric Features (28%) and Traffic Characteristics (12%)	Geometric Features (70%)	Horizontal Curve(15%)	6
		Sight Distance(20%)	8
		Lane Width(10%)	4
		Shoulder Width(10%)	4
		Pavement Ratio(5%)	2
		Crosswalk(10%)	4
		Sum	28
	Traffic Characteristics (30%)	Traffic Volume(20%)	8
		Heavy Vehicle Ratio(10%)	4
		Sum	12
Government Opinions(10%)			10
Total			100

5.1 Selection Standards According to The Accident Severity

Method considering the accident severity is applied by calculating the index "traffic accident" according to the method used in the project "selecting preference project for frequent accident area".

- Calculating Method : Traffic accident index is calculated using below equation.

$$ROPI_i = \left(\frac{NOA_i}{\sum_{i=1}^{n} NOA_i} + \frac{EPDO_i}{\sum_{i=1}^{n} EPDO_i}\right) \times 100 \qquad \text{Equation 8}$$

where, NOA_i : # of accidents in i section, $EPDO_i$: Accident severity in i section($=\Sigma P_j NS_j$),
P_j : Weighting factor of person's accident, NS_j : # of accidents relating person's accident

In case of the weighting factor, its value is added for each type of accidents by categorizing accidents with human damage into death, serious and slight injury. Value for adding weight was based on the value proposed in "Guidelines for Location of Frequent Accident, Ministry of Construction and Transportation, 2002. 10", in which the death and injury causing accidents' values were calculated based on slight injury(slight injury = 1).

Table 6. Weighting Factor Calculation

	Death	Serious Injury	Slight Injury
Guidelines	179.79	19.74	6.3
This study	28.53	3.13	1

- Scoring Method (50 points) : Traffic accident index calculated using equation 8 was summarized in an order to be scored according to the comparative evaluation for subjected sections.

Table 7. Scoring Method According to Traffic Accident Index

Relative Ratio	Above 20%	20 ~ 40%	40 ~ 60%	60 ~ 100%
Score(Point)	50	40	30	20

5.2 Selection Standard According to Geometric Features

5.2.1 Horizontal Curve

The risk of accident in horizontal curve has been proven through the analysis on the features of accidents on provincial roads and preceding research results. The radius of horizontal curve in provincial roads can be installed up to 140~280m according to the design speed and is scored according to the relative assessment for each subjected section. Following is the radius standard according to the design speed.

Table 8. Radius Standard for Plane Curve for Design Speed

Classification	Unit	Design Speed(km/h)			
		80	70	60	50
Min. Radius	m	280	200	140	90

Geometric feature standards for provincial roads is 60~80km/h for ground level and 50~60km/h for mountain level.

- Calculation method : # of under standard radius / Section length(km)
- Scoring Method (6 points) : The calculated value is summarized in the order to be scored by relative assessment for each subjected section.

Table 9. Scoring Method according to Number of Curve Section

Relative Ratio	Above 10%	10 ~ 20%	20 ~ 30%	30 ~ 50%	The Rest
Score(Point)	6	4.5	3	1.5	-

5.2.2 Sight Distance

Sight distance defect is the major cause of accidents such as front collision and others frequently occurring in provincial roads. Therefore, the score should be high if the ratio of sight distance defect section is high. Sight distance defect section refers to the standard less than the minimum sight distance standard according to the speed. Shown below is the minimum sight distance standard according to each design speed.

Table 10. Minimum Sight distance Standard according to Design Speed

Design Speed(km/h)	50	60	70	80	90	100
Sight Distance(m)	65	85	110	140	170	200

Data: Regulations on the Road Structure and Facility Standard, (Ministry of Construction and Transportation, 2000. 03)

- Calculation Method : # of S.D defect sections / Section length
- Scoring Method (8 points) : The calculated value is summarized in the order to be scored by relative assessment for each subjected section.

Table 11. Scoring Method According to Number of Sight Distance Defect Section

Relative Ratio	Above 10%	10 ~ 20%	20 ~ 30%	30 ~ 50%	The Rest
Score(Point)	8	6	4	2	-

5.2.3 Lane Width

It has been proven that the risk of accidents is higher with narrow lane width according to the preceding researches. Therefore, more score is given to lane with narrower mean width. The minimum lane width standard is 3.0m ~ 3.5m according to the designing speed.
- Calculation Method : Calculation method according to the lane width is mean lane width (m) of subjected sections.
- Scoring Method (4 points) : Following is the scoring method according to lane width.

Table 12. Scoring Method According to Lane Width

Lane Width	Above 3.5m	3.25 ~ 3.5m	3.0 ~ 3.25	Under 3.0
Score(Point)	-	1	2.5	4

5.2.4 Shoulder Width

Shoulders of the road can be used to install safety facilities or as pedestrian area, and correlation with accidents had been proven by preceding researches. Therefore, score is granted more at narrower shoulder width. According to Korean Highway Capacity Manual (2001), shoulder width under ideal condition[5] of provincial road is 1.5m or more. In case of unpaved shoulders, pavement is serious matter, so 4 point (the highest point) is given regardless of the shoulder width.
- Calculation Method : Calculation method according to the shoulder width is mean shoulder width (m) of subjected sections.
- Scoring Method (4 points) : Following is the scoring method according to shoulder width.

Table 13. Scoring Method According to Shoulder Width

Shoulder width	Non-Pavement	Pavement	
		0m(4P) ~ 1.5m(0P)	Above 1.5m
Score(Point)	4	Interpolation	-

5.2.5 Crosswalk

Provincial roads have high accident rate during pedestrian's crossing the road. Therefore, considering the ratio of the crossroads, higher score is given to higher number of crosswalk.
- Calculation method : # of crosswalks in section / section length(km)
- Scoring Method (4 points) : Following is the scoring method according to the number of crosswalks in a section.

Table 14. Scoring Method According to the Number of Crosswalk in a Section

Relative Ratio	Above 10%	10 ~ 20%	20 ~ 30%	30 ~ 50%	The Rest
Score(Point)	4	3	2	1	-

[5] Condition of a road operating in free flow status

5.2.6 Pavement Ratio

Unpaved roads can influence the accidents due to degraded sense of boarding. Therefore, higher score is given to lower ratio of pavement. The average pavement ratio of provincial roads is shown as 78.9%.

- Calculation Method: Calculation method according to the pavement ratio is calculated by the existence of road pavement.
- Scoring Method (2 points) : Following is the scoring method according to pavement ratio.

Table 15. Scoring Method According to Pavement Ratio

Pavement Ratio	Non-Pavement	Partial Pavement	Pavement
Score(Point)	2	1	-

5.3 Selection Standard According to Traffic Features

5.3.1 Traffic Volume

Higher traffic volume refers to increased cases of accidents. This fact has been proven by preceding researches. Therefore, roads with higher traffic volume are called hazardous roads.

- Calculation Method : Calculate by using the ADT (vehicles/day) of each lane of subjected section.
- Scoring Method (8 points) : Following is the scoring method according to the traffic volume. Means and distribution for traffic volume has been collected for number of lanes using daily traffic volume of provincial roads presented in "Road Traffic Volume Statistical Report (Ministry of Construction and Transportation, 2002)". And the figure was applied for the scoring method.

Table 16. Scoring Method According to Traffic Volume

	Both Sides Direction		
	Sub Value (veh/day)	Med Value (veh/day)	Upper Value (veh/day)
1	100	100~1,630	1,630
2	130	130~9,300	9,300
4	6,500	6,500~34,500	34,500
6	27,900	27,900~70,400	70,400
8	61,400	61,400~76,200	76,200
Score(Point)	3	5	8

ADT in each category shown in Table 16 had been calculated as shown below.

- Sub Value : ADT < μ - σ of subjected section
- Mid Value : μ - σ < ADT < μ + σ of subjected section
- Upper Value : ADT > μ + σ of subjected section

Here, μ : Mean ADT for Number of Lanes σ : Distribution

5.3.2 Heavy Vehicle Ratio

Higher rate of heavy vehicle is known to increase the number and severity of the accidents. Therefore, higher score is given to the section with high ratio of heavy vehicles. According to the "Road Traffic Volume Statistical Report(Ministry of Construction and Transportation, 2002)", heavy vehicle is categorized into bus and truck. The mean of daily heavy vehicle in provincial roads is 44.5%.

- Calculation Method : (Heavy vehicle volume / Traffic volume) x 100(%)
- Scoring Method (4 point) : Score by Interpolation if the ratio is 45% or lower. It is considered that the number and severity of accident is high regardless of the percentage if the ratio is 45% or higher.

Table 17. Scoring Method According to Heavy Vehicle Ratio

Heavy Vehicle Ratio	Below 45%(0% : 0 P)	Above 45%
Score(Point)	Interpolation	4

Below is the summary of calculation and scoring methods of each item presented above.

Table 18. Calculation and Scoring Methods According to Assessment Items

Assessment Index	Calculation Method		Score (Point)
Accident Severity (50%)	Above 20%		50
	20 ~ 40%		40
	40 ~ 60%		30
	60 ~ 100%		20
Total(40%)	Relative Assessment(100%)	Sum of Index	40
geometric features (28%)	Horizontal Curve(15%)	# of Under Standard Radius / Section Length	6
	Sight Distance(20%)	# of S.D Defect Section / Section Length	8
	Lane Width(10%)	Mean of Lane Width	4
	Shoulder Width(10%)	Mean of Shoulder Width	4
	Pavement Ratio(5%)	Existence of Pavement	2
	Crosswalk(10%)	# of Crosswalk in Section / Section Length	4
traffic characteristics (12%)	Traffic Volume(20%)	ADT per Lane	8
	Heavy Vehicle Ratio(10%)	Heavy Vehicle Volume / Traffic volume	4
local government opinions (10%)	High Demands of Local Government		10
	Medium Demands of Local Government		8
	Low Demands of Local Government		5

6. Conclusion

This research proposes the standard for selecting hazardous roads in provincial roads. To provide realistic standard, we have fully understood the status of provincial roads as of year 2002 and had studied and analyzed the data of accidents occurring in provincial roads (years 2000~2002) to drive its features. Also by studying previous researches, we have collected elements of hazardous roads. Through this process, we have selected accident severity, traffic characteristics, geometric features and local government opinions to be the elements necessary in selecting hazardous roads. Also the weight importance of these elements had been calculated using AHP method. As a result, the importance level has been collected in the order of accident severity, geometric features, traffic characteristics and local government opinions. Assessment items had been scored according to their features shown below using the features of accidents occurring in provincial roads and researches conducted in the past.

- Accident Severity : Traffic Accident Coefficient
- Geometric Features : Horizontal Curve, Sight Distance, Lane Width, Shoulder Width, Crosswalk, Pavement Ratio
- Traffic Characteristics : Traffic Volume, Heavy Vehicle Ratio
- Local Government Opinions

It is judged that using the result of this research can maximize the efficacy of road traffic safety management project since it can select hazardous roads adding existence method of selecting hazardous roads using only number of accidents to the road and traffic characteristics. Also, this research is different from the ones in the past in a way that old researches used mathematical and statistical equations which can be difficult to apply in actual cases. On the contrary, this research had made it easy to apply site application. Also statistical interpretation could be used considering the uncertainties of car accidents. Lastly, considering the diversity of accident factors, elements of car accidents had been reflected and also the research had considered the unique risk of accidents in each spot. From the data on provincial roads used in this thesis, we hereby specify that only the limited data had been used for the analysis for geometrical structures because the database construction was not performed appropriately. Also, once it is possible to collect more data related to geometric features in the future, the results presented in this thesis may differ from the ones to be driven in the future researches.

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