Construction of the Accident Correlation Models for Predicting the Accident Occurrence Patterns in Korea

By
Fady Mohammed Abdallah Hassouna

Department of Civil and Environmental Engineering
Graduate School
Korea Maritime University

ABSTRACT

Motor vehicles have been continuously increasing with the development of the technologies and the increase of the travel demands, which has become a cause to increase the number of the traffic accidents and worsen the social problems from a social and economic point of view all over the world, especially in the developing countries. However, the number of traffic accidents in Korea as well as in the United States has continuously shown a trend to decrease since 2000, despite the increase of the motor vehicles registered. And a proper relationship has never been seen between the accident factor characteristics found in Korea.

The purpose in this study is to investigate 5-year traffic accident data in Korea from 2000 to 2004, analyze the accident factor characteristics based on those 5-year traffic accident data, construct the accident correlation models which could predict the accident occurrence patterns in the future based on the accident factor characteristics, and verify the accident correlation models constructed with the t-test and correlation analysis such that the accident occurrence patterns could be predicted by the proper relationship between traffic accident factor characteristics in Korea.

From the results of the development and validation of the accident correlation model with the accident factor characteristics, the conclusions were drawn as follows;

ⅰ) Traffic accident patterns showed a uniform pattern with the 3-dimensional polynomial shift curve and a high determination coefficient (R^2) for each accident factor characteristics. However, the percent of traffic accidents showed almost an equal percent for each year, even if traffic accidents have continuously reduced since 2000.

ⅱ) More traffic accidents occurred during the 2-hour period right after the rush hour in the afternoon than any other time periods, the daytime period than the nighttime period, the day before weekend than any other weekdays, and from March to October than any months, according to the periodic factor characteristics.

ⅲ) More traffic accidents occurred in the Capital Region than any other regions, in the intersection than any other locations, on the national highway than any other road types, in the suburban area than any other area types, and by passenger cars than any other vehicle types, according to the non-periodic factor characteristics.

ⅳ) Accident correlation models showed a very high explanatory power between the last 2 years before and after, and also a very high correlation between the expected and observed data, except for weekday, monthly, seasonal, area type factor characteristics based on the development and verification of the accident correlation models.

ⅴ) Traffic accident patterns showed a very high correlation with the 3-dimensional polynomial shift curves except for the monthly factor (R^2=0.5231) in the periodic factor characteristics and the regional factor (R^2=0.8542) in the non-periodic factor characteristics.

ⅵ) Traffic accident patterns particularly showed a much higher correlation with the 3-dimensional polynomial shift curves, when compared with the traffic accident patterns of the accident factor characteristics classified into the daytime and nighttime periods than those characteristics not classified into the daytime and nighttime periods.

Therefore, since the accident occurrence patterns in Korea were thought to show the equal patterns after 2004, especially except for the area type factor characteristics, the appropriate counter-measures to be established for the reduction of traffic accidents. Also, more accident occurrence patterns in the future were needed to be studied for the accident factor characteristics such as age, sex, or drinking of driver, if possible.

한국의 교통사고 발생행태 추정을 위한 교통사고 상관모형의 구축

파디 하수나

한국해양대학교 대학원 토목환경공학과

논문요약

지금까지 자동차는 과학기술의 발달과 통행수요의 증가와 함께 지속적으로 증가하여 왔다. 게다가 자동차의 증가는 교통사고 증가의 주요 원인이 되고 있고, 특히 개발도상국가에서는 사회·경제적 관점에서 사회문제를 더욱 악화시키는 원인이 되고 있다.

2000년 이후 미국뿐만 아니라 한국에서도 등록차량 수의 증가에도 불구하고, 교통사고의 발생 건수가 감소하는 추세를 보이고 있는 상황이다. 그러나 아직까지 한국에서는 이러한 교통사고 요인특성 사이의 상호 관계에 관한 적절한 연구가 없었다. 따라서 이 연구의 목적은 지난 2000년부터 2004년까지의 한국에서 발생한 5년간의 교통사고자료를 중심으로 사고요인특성 및 발생행태를 분석하고, 사고요인특성 및 발생행태의 분석결과에 따라 2002년을 기반으로 교통사고의 상관모형을 구축하며, 상관모형에 의한 예측자료와 관측자료 사이의 t-검증과 상관분석을 통해 상관모형을 검증함으로써 장래 한국에서 예상되는 교통사고 발생행태를 추정할 수 있도록 하는 데 있다.

교통사고의 분석결과와 상관모형의 구축·검증을 통해 다음과 같은 결론에 도달하게 되었다.

ⅰ) 교통사고의 발생행태는 3차원의 곡선 행태를 보였고, 높은 결정계수 값(R^2)을 나타내었다. 그러나 2000년 이후 교통사고가 감소했다고 할지라도 교통사고의 발생비율에는 큰 차이를 보이지 않았다.

ⅱ) 주기적 요인특성분석에서는 특히, 퇴근시간 후 2시간 동안에, 낮 시간 동안에, 주말 하루 전날에 그리고 3월에서 10월 사이에 상대적으로 교통사고의 발생건수가 많은 것으로 나타났다.

ⅲ) 비주기적 요인특성분석에서는 특히, 수도권지역에서, 교차로에서, 국도상에서, 부도심지역에서 그리고 승용차에 의해서 상대적으로 교통사고의 발생건수가 많은 것으로 나타났다.

ⅳ) 2002년을 기준으로 이전 2년간 자료와 이후 2년간 자료가 교통사고 상관모형의 변수로 사용되었으며, 요일 별, 월별, 계절별 그리고 지역별 요인특성을 제외하고는 높은 상관관계를 보이는 것으로 나타났다.

ⅴ) 교통사고 상관모형을 구축·검증한 결과, 주기적 요인특성분석에서는 월별 요인특성(R^2=0.5231)과 비주기적 요인특성분석에서는 지역별 요인특성(R^2=0.8542)을 제외하고는 높은 상관관계를 보이는 것으로 나타났다.
ⅵ) 주기적 요인특성과 비주기적 요인특성을 낮과 밤 시간대로 분류하여 교통사고 상관모형을 구축·검증한 결과, 보다 높은 상관관계를 보이는 것으로 나타났다.

그러므로 한국에서의 교통사고 발생행태는 2004년 이후에도 상당기간 동일한 발생행태를 보일 것으로 생각되므로 교통사고의 감축을 위한 적절한 대책이 강구될 필요가 있다고 생각된다. 또한 향후 연구과제로는 가능하다면 운전자의 나이별, 성별 및 음주여부의 요인특성에 대한 교통사고 발생행태에 대한 연구도 이루어질 필요가 있다고 생각된다.

ACKNOWLEDGEMENT

Writing of this thesis wouldn’t have been possible without support of my advisor, colleagues and my family. First and foremost I would like to express my deepest gratitude to Professor Kim Taegon, Professor Lee Joongwoo, Professor Kim Dosam, Professor Kyeung Gapsoo, and Professor Kim Taehyeung for their invaluable guidance, support, advice and spending long time and effort to improve this thesis.

I would like to thank my colleagues in the Highway and Traffic Engineering Laboratory (HTEL) for their help and cooperation during my stay at Korea Maritime University. Also, I would like to thank my parents and all of my family for their support and encouragement in Palestine, while I’m in Korea for the Master Program.

Contents

Nomenclature

β_0, β_1	:	Regression coefficients
Xaft	:	The no. of accidents occurred for the last 2 years after
Xbef	:	The no. of accidents occurred for the last 2 years before
R^2	:	Determination coefficients
r	:	Correlation coefficients
p-value	:	Probability
α	:	Level of significance
Houaft	:	The no. of accidents occurred during the 2-hour periods
Dayaft	:	The no. of accidents occurred during the day-and-night periods
Weeaft	:	The no. of accidents occurred during the weekdays
Monaft	:	The no. of accidents occurred during the months
Seaaft	:	The no. of accidents occurred during the seasons
Regaft	:	The no. of accidents occurred within the regions
Locaft	:	The no. of accidents occurred at the locations
Higaft	:	The no. of accidents occurred on the roads
Areaft	:	The no. of accidents occurred in the areas
Vehaft	:	The no. of accidents occurred by the vehicles
Mdyaft	:	The no. of monthly accidents occurred during the daytime periods
Mntaft	:	The no. of monthly accidents occurred during the nighttime periods
Sdyaft	:	The no. of seasonal accidents occurred during the daytime periods
Sntaft	:	The no. of seasonal accidents occurred during the nighttime periods
Hdyaft	:	The no. of road type accidents occurred during the daytime periods
Hntaft	:	The no. of road type accidents occurred during the nighttime periods
Adyaft	:	The no. of area accidents occurred during the daytime periods
Antaft	:	The no. of area accidents occurred during the nighttime periods
Vdyaft	:	The no. of vehicle type accidents occurred during the daytime periods
Vntaft	:	The no. of vehicle type accidents occurred during the nighttime periods
Houbef	:	The no. of accidents occurred during the 2-hour periods
Daybef	:	The no. of accidents occurred during the day-and-night periods
Weebef	:	The no. of accidents occurred during the weekdays
Monbef	:	The no. of accidents occurred during the months
Seabef	:	The no. of accidents occurred during the seasons
Regbef	:	The no. of accidents occurred within the regions
Locbef	:	The no. of accidents occurred at the locations

Arebef	：	The no. of accidents occurred in the areas
Vehbef	：	The no. of accidents occurred by the vehicles
Higbef	：	The no. of accidents occurred on the roads
Mdybef	：	The no. of monthly accidents occurred during the daytime periods
Mntbef	：	The no. of monthly accidents occurred during the nighttime periods
Sdybef	：	The no. of seasonal accidents occurred during the daytime periods
Sntbef	：	The no. of seasonal accidents occurred during the nighttime periods
Hdybef	：	The no. of road type accidents occurred during the daytime periods
Hntbef	：	The no. of road type accidents occurred during the nighttime periods
Adybef	：	The no. of area type accidents occurred during the daytime periods
Antbef	：	The no. of area type accidents occurred during the nighttime periods
Vdybef	：	The no. of vehicle type accidents occurred during the daytime periods
Vntbef	：	The no. of vehicle type accidents occurred during the nighttime periods
Houexp	：	The no. of accidents expected by the hourly factor model
Dayexp	：	The no. of accidents expected by the day-and-night factor model
Weeexp	：	The no. of accidents expected by the weekday factor model
Monexp	：	The no. of accidents expected by the monthly factor model
Seaexp	：	The no. of accidents expected by the seasonal factor model
Regexp	：	The no. of accidents expected by the regional factor model
Locexp	：	The no. of accidents expected by the location factor model
Higexp	：	The no. of accidents expected by the road type factor model
Areexp	：	The no. of accidents expected by the area type factor model
Vehexp	：	The no. of accidents expected by the vehicle type factor model
Mdyexp	：	The no. of accidents expected by the month and daytime factor model
Mntexp	：	The no. of accidents expected by the month and nighttime factor model
Sdyexp	：	The no. of accidents expected by the season and daytime factor model
Sntexp	：	The no. of accidents expected by the season and nighttime factor model
Hdyexp	：	The no. of accidents expected by the road type and daytime factor model
Hntexp	：	The no. of accidents expected by the road type and nighttime factor model
Adyexp	：	The no. of accidents expected by the area type and daytime factor model
Antexp	：	The no. of accidents expected by the area type and nighttime factor model
Vdyexp	：	The no. of accidents expected by the vehicle type and daytime factor model
Vntexp	：	The no. of accidents expected by the area type and nighttime factor model

List of Figures

List of Tables

List of Figures in Appendices

Chapter 1 Introduction

1.1 Background

Motor vehicle accident defines any event that results in unintended injury or property damage attributable directly or indirectly to the motion of a motor vehicle or its load, and motor vehicle traffic accident does any motor vehicle accident occurring on any highway, street, or road, or anyway or place of which any part is open for the use of the public (AASHTO, 1983). Motor vehicle has been continuously increasing with the development of the technologies and the increase of the travel demands, which has become a cause to increase the number of the traffic accidents and worsen the social problems from a social and economic point of view all over the world, especially in the developing countries.

When compared with the transportation conditions based on the highway statistics of the Federal Highway Administration (FHWA) and the accident statistics of the Census Bureau in the United States, as of 2004, there were 293 million people in population and about 4,800 thousand miles in the length of the national and state highway (FHWA, 2007), and there were also about 43,000 people killed and about 2.8 million people injured in motor vehicle accidents each year (U.S. Census Bureau, 2007). Particularly, the number of the motor vehicles registered in the United States was about 240 million vehicles in 2004 with the increase rate of about 1.8 % each year from 2001 to 2004 as shown in Table 1.1. However, the total number of traffic accidents including fatal accidents and injury ones gradually showed a pattern to decrease after 2000, even if the number of fatal accidents gradually showed a pattern to increase from 2000 to 2002 and decrease again after 2002. That is, the total number of traffic accidents was shown to have gradually decreased since 2000, which was thought to be caused by the improvement of the transportation means and facilities, the development of the information and telecommunication, and the introduction of the intelligent transportation systems (ITS) to the transportation fields in the United States.

Table 1.1 Population, accident, and highway statistics in the United States

Year	Population	Roadway length	Registered vehicle	Fatality	Injury
2000	281,425,000	4,711,525 miles	221 millions	41,900	3,189,000
2001	285,108,000	4,723,924 miles	-	42,200	3,033,000
2002	287,985,000	4,743,086 miles	230 millions	43,000	2,926,000
2003	290,850,000	4,766,964 miles	231 millions	42,900	2,889,000
2004	293,657,000	4,776,704 miles	237 millions	42,600	2,788,000

Source: FHWA and U.S. Census Bureau, 2007.

When compared with the transportation conditions in Korea based on the accident statistics in the Road Traffic Safety Authority (RTSA) and the highway statistics in the Ministry of Construction and Transportation (MOCT), as of the end of 2004, the population was about 48.2 million people, the total length of roadways about 100.3 thousand km (MOCT, 2007), and the total number of traffic accidents about 220.1 thousands in Korea (RTSA, 2007). Along with the rapid increase of automobiles at about the same time of 1988 Seoul Olympic Game, the number of the traffic accidents in Korea has continuously increased by 2000, and since then gradually decreased by 2004 as shown in Fig. 1.1.

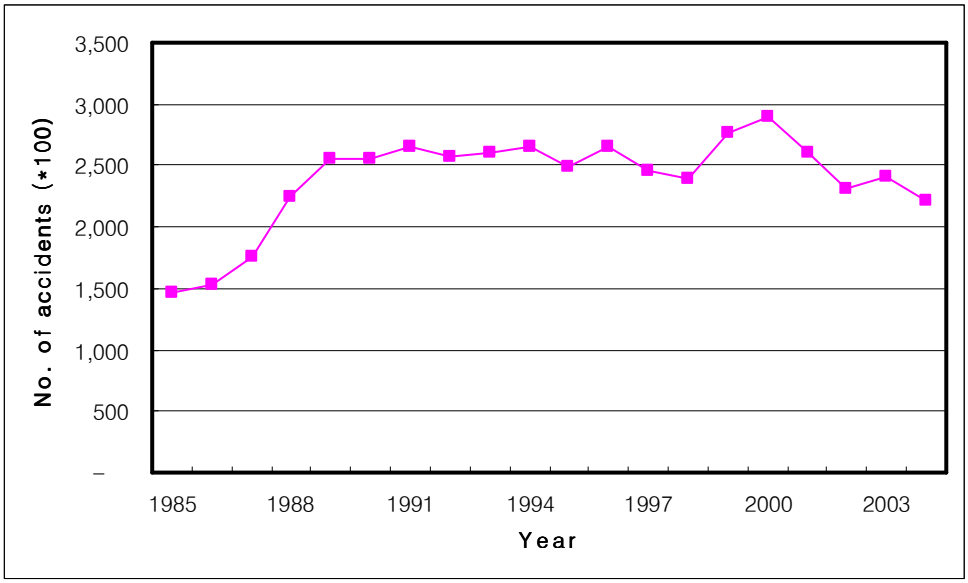

Fig. 1.1 Pattern of traffic accidents from 1985 to 2004 in Korea

Particularly, the number of traffic accidents showed 21.7 accidents/100,000 people in 2000 and gradually decreased to 13.6 accidents/100,000 people in 2004, based on 100,000 people in population. Additionally, the number of traffic accidents showed about 24.1 accidents/1,000 motor vehicles in 2000 and about 14.8 accidents/1,000 motor vehicles in 2004 based on the 1,000 registered motor vehicles. Also, the number of traffic accidents showed about 3.3 accidents/km in 2000 and about 2.2 accidents/km in 2004 based on the length of roadway, as shown in Table 1.2. That is, the total number of traffic accidents was shown to have gradually decreased since 2000, which was thought to be caused by the expansion of the new transportation facilities, improvement of the existing transportation facilities, the development of the information and telecommunication, and the introduction of the intelligent transportation systems (ITS) to the transportation means and facilities in Korea.

Table 1.2 Population, accident, and highway statistics in Korea

Year	Population	No. of accidents	Registered vehicle	Roadway length
2000	47,008,000	290,481	12,059,276	88,775
2001	47,343,000	260,579	12,914,115	91,396
2002	47,640,000	231,026	13,949,440	96,037
2003	47,925,000	240,832	14,586,795	97,253
2004	48,199,000	220,755	14,934,092	100,278

Source: RTSA and MOCT, 2007.

As described in the above, the number of traffic accidents has continuously shown a pattern to decrease in Korea and the United States since 2000, despite the increase of the registered motor vehicles. However, a proper relationship has never been seen between the traffic accident characteristics and the accident factors found in Korea.

Thus, the purpose of this study was to collect and investigate 5 year traffic accident data in Korea from 2000 to 2004, compare and analyze the accident factor characteristics based on those 5 year traffic accident data, construct and verify the accident correlation models which could predict the traffic accident patterns in the future based on the accident factor characteristics, and finally find and suggest the proper relationship between traffic accident factor characteristics in Korea.

1.2 Literature Review

In the traffic accident study by **Orne, D. E. et al. (ITE, 1972) in US**, more emphasis was put on the priority rankings among the weather factors having an effect on traffic accidents by stepwise regression analysis. In particular, the priority rankings among the weather factors were shown to have an effect on traffic accidents, which were 1) precipitation, 2) temperature, 3) pavement condition, 4) lighting, 5) pressure, 6) relative humidity, 7) season variation and wind speed through the stepwise regression analysis. Additionally, polynomial regression analysis for season pressure alone was shown to have a strong effect on accident rate due to the change of pressure. What was more, low air pressure was shown to correspond with the higher accident rates, the change of accident rate shown to be higher during low pressure periods, and low temperature periods shown to have much higher accident rates.

In the traffic accident study **by Khedaywi, T. S. et al. (ITE, 1987) in Jordan**, the causes of traffic accidents were classified into inattention, not giving way to traffic having and over speed depending on the city and governorate. Particularly, the first largest cause of the monthly traffic accidents was shown to be ‘inattention’ for both the

city and the governorate, which cause of accidents was shown to be 58.2% of traffic accidents in the city and 59.0% in the governorate. Also, the second largest cause of traffic accidents was shown not to be giving way to traffic having priority (11.5%) in the city, whereas it was shown to be over speed (ll.0%) in the governorate. In addition, the more frequently cited “over speed” cause was shown to correlate with the higher number of accidents involving overturning vehicles in the governorate, which could be partially attributed to the higher speed limits on the governorate roads.

In the traffic safety study by **Jadaan, K. S. (ITE, 1993) in New Zealand**, fatal accidents were classified into age and sex of road users for identifying the causes of traffic accidents. Particularly, young male drivers were shown to be at risk when investigated fatality patterns. In addition, drunken drivers were shown to contribute significantly to traffic deaths, and a substantial number of drivers involved in accidents not to use them despite the fact that wearing seat belts was compulsory. In order to reduce the accident death rate in New Zealand, the remedies such as clear policy objective, specific budget, vehicles with new design features, new technologies to control, and more research in road safety were shown to be called for.

In the traffic accident study by **Choueiri, E. M. et al. (ITE, 1997) in Lebanon**, traffic accidents were classified into age and sex of road users, accident location, and accident type for identifying the severities and the causes of accidents. And methods and techniques were used to reduce the number of accidents and the physical features of roads and vehicles in order to set the stricter rules and regulations with respect to their safety requirements. Particularly, a strict traffic law was shown to be enforced, emergency medical services shown to be provided, a proper road maintenance program shown to be established, proper safety precautions shown to be taken, road and intersection improvement shown to be implemented, and adequate highway drainage and sufficient road safety facilities shown to be equipped. In addition, comprehensive traffic regulation schemes were shown to be prepared, regular medical supervision of drivers and mandatory periodic eyesight tests shown to be executed, road safety education shown to be enforced, and public transit systems using a combination of rail, bus and jitney shown to be set up.

In the traffic accident study **by Park, J. S. (1998) in Korea**, the accident types in the intersection were identified and also regression models developed. Particularly, the principal types in the intersection accidents were found to be the rear-end accidents, and the accident rate by motor-cycle in the intersection accidents was shown to be higher than any other accident locations. In addition, most of the intersection accidents were shown to occur within the intersection and near the intersection when compared with the

location of the intersection accidents. What was more, the accident models developed by the regression models using principal component scores, which established the principal component score as the explanatory factor, were shown to have a higher fitness and a lower standardized residual than those which established the accident factors as the explanatory factors.

In the traffic accident study **by Kim, J. S. (2001) in Korea**, the traffic accident factors were classified into human factor, vehicle factor, and road-environmental factor with the characteristic analysis of the intersection accidents. And the influence level of these factors to traffic accidents was investigated, and the appropriate direction for reducing the traffic accidents suggested. Particularly, the intersection accidents to occur between 4 o'clock in the afternoon and 2 o'clock in the morning were shown to be more than those in the remaining periods. The total traffic volume to intersection was shown to have a high correlation with the traffic accident indicator. Also, the rear-end and side-swipe accidents within the intersection were shown to have a comparatively high correlation with the average distance between the vehicles.

In the traffic accident study **by Choi, K. T. (2003) in Korea**, the multiple regression models were constructed by using the number of traffic accidents, the killed, and the wounded as the dependent factors, and population, passenger transportation, traffic signal, and traffic control as the independent ones. The regression models were shown to have a very high correlation of more than 0.9 between the independent and dependent factors with higher accuracy and confidence for predicting traffic accidents and socio-economic indices under the assumption that the accident shift patterns would be continued in the future.

In the traffic accident study **by Lee, I. S. (2004) in Korea**, the regression models were developed, and also compared whether the models were appropriate for the traffic characteristics or not. Particularly, the covariates such as speed limit or number of lanes on the roads were thought to be the factors which impacted the number of traffic accidents. Additionally, zero-inflated Poisson regression models, negative binomial regression and zero-inflated negative binomial regression models, as the regression models fitted for the killed accident characteristics, were suggested, instead of Poisson regression model.

1.3 Data Collection

Data for the study area including traffic data, roadway data and accident data were compiled from the Ministry of Construction and Transportation (MOCT) in Korea, the Road Traffic Safety Authority (RTSA), the Korean Statistical Information System

(KOSIS), and the Korean Insurance Development Institute (KIDI) from 2000 to 2004. Data from the Ministry of Construction and Transportation in Korea included Average Daily Traffic (ADT) volumes and the length of roadway. Data from the Road Traffic Safety Authority (RTSA) included the time periods, the regions, and the locations, the area-types, the road types, and the vehicle types of accidents. Data from the Korea Insurance Development Institute (KIDI) included the cost of accidents. Data from the Korean Statistical Information System (KOSIS) included the number of accidents depending on the fatalities and injuries. However, some of data from MOCT, KIDI, and KOSIS were missing and excluded, when compared with data from RTSA of 2000 to 2004. So, a master dataset were generated by data which were obtained from the Ministry of Construction and Transportation (MOCT) in Korea and the Road Traffic Safety Authority (RTSA) if possible.

1.4 Study Process

For the purpose of finding the proper relationship between the traffic accident factor characteristics, the study process was as follows;

ⅰ) Start the study in order to identify the relationship between the accident factor characteristics.

ⅱ) Determine the background and objective of the study in order to identify the relationship between the accident factor characteristics.

ⅲ) Review the traffic accident related literatures.

ⅳ) Collect and analyze 5 year traffic accident data from the Road Traffic Safety Authority (RTSA) and the Ministry of Construction and Transportation (MOCT) in Korea.

ⅴ) Identify the accident factor characteristics classified into the periodic factors, the non-periodic factors, and cross factors.

ⅵ) Construct the accident correlation models for predicting the accident occurrence patterns, whether the accident occurrence patterns in the future would be continuously maintained or not.

ⅶ) Verify the accident correlation models with the expected accident data and the observed ones by t-test and correlation analysis.

ⅷ) Reach the conclusion on the accident factor characteristics and suggest the proper measures for reducing traffic accidents.

ⅸ) End the study by finding the proper relationship between the accident factor characteristics.

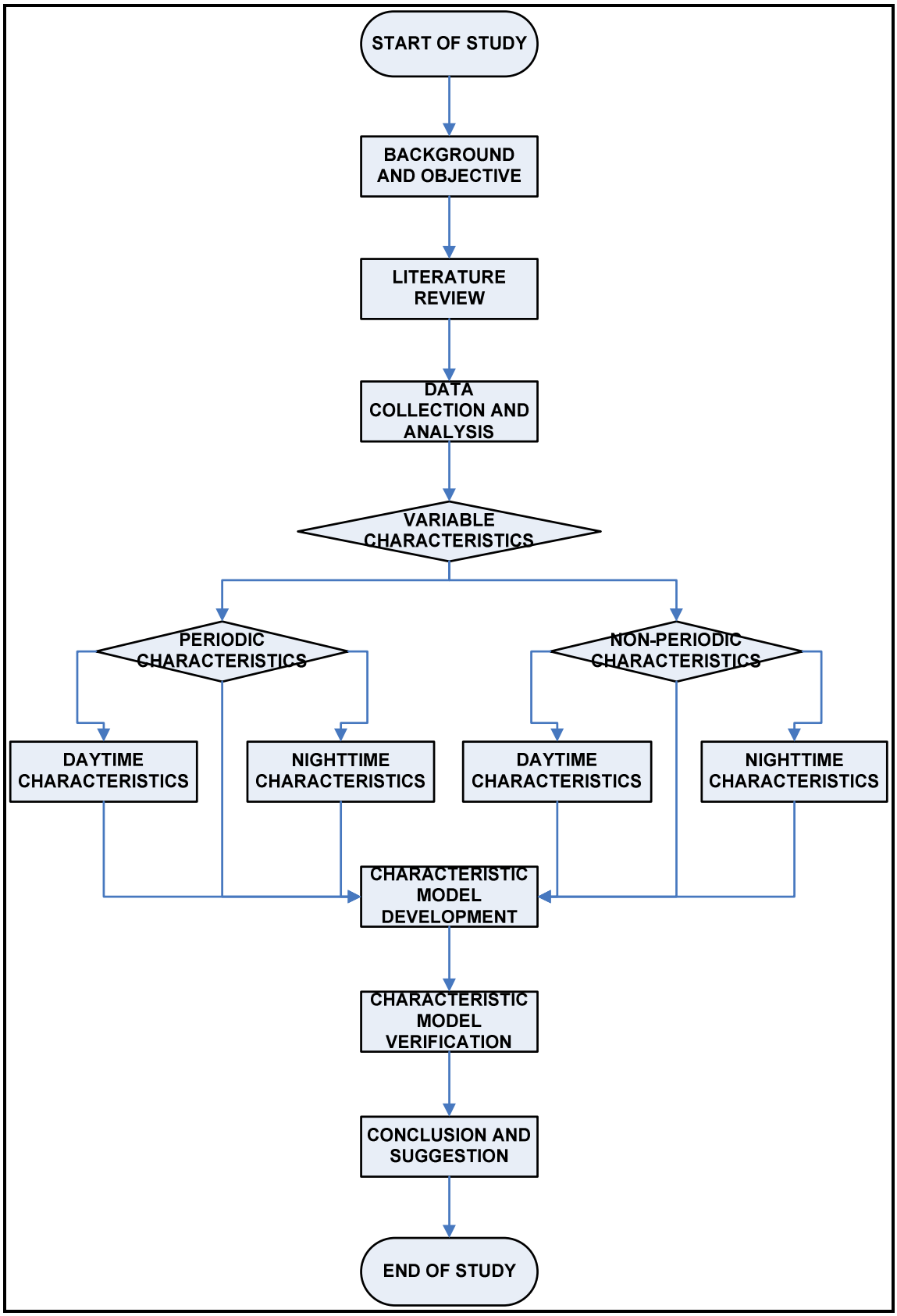

Fig. 1.2 Flowchart of study process

Chapter 2 Traffic Accident Analysis

For the traffic accident analysis, accident data of 2000 to 2004 were classified into the periodic factors, the non-periodic factors and the cross factors. Particularly, there were the hourly factor, the day-and-night factor, the weekday factor, the monthly factor and the seasonal factor in the periodic factors. There were the regional factor, the location factor, the road type factor, the area type factor, and the vehicle type factor in the non-periodic factors. There were the month and day-and-night factor, the season and day-and-night factor, the road type and day-and-night factor, the area type and day-and-night factor, and the vehicle type and day-and-night factor in the cross factors. Also, a comparison for each accident factor in the above was made from the standpoints of the number of accidents and the percent of accident, respectively.

2.1 Accident Analysis by the Periodic Factor Characteristics

2.1.1 Accident analysis by hourly factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred every two-hour period of a whole day for the last 5 years of 2000 to 2004.

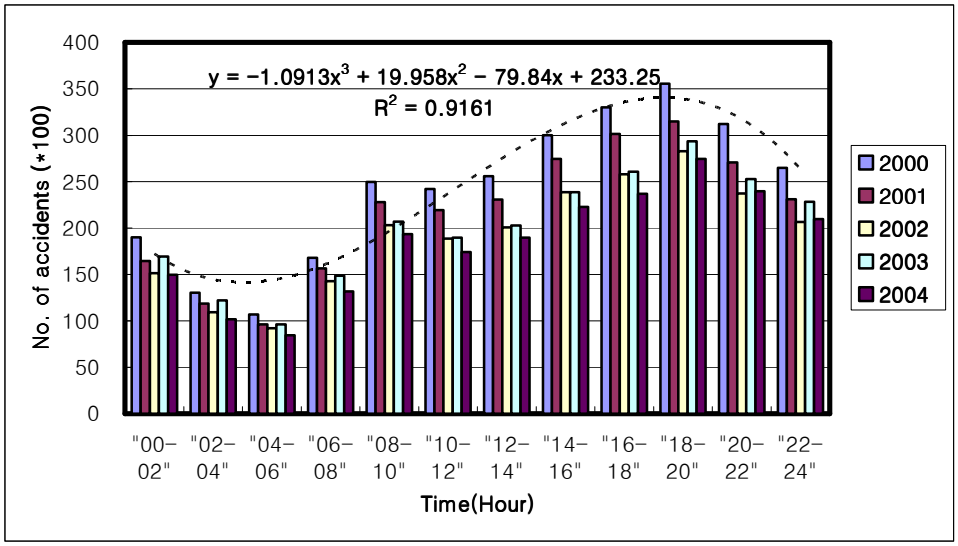

Fig. 2.1 Accident patterns by hourly factor characteristics

The number of accidents has gradually decreased since 2000, except for 2003. Also, the number of accidents occurred in the afternoon periods were shown to be much more than those occurred in the morning periods by shaping the 3-dimensional polynomial shift curves as shown in Fig. 2.1. In addition, the number of accidents occurred during the

two-hour period right before the rush hour (4 o'clock to 6 o'clock) in the morning periods were shown to be very low, but those occurred during the two-hour period right after the rush hour (6 o'clock to 8 o'clock) in the afternoon periods shown to be very high throughout the last 5 years, as shown in Fig. 2.1.

On the one hand, compared with the number of accidents occurred in the morning and afternoon periods of a whole day for the last 5 years, the results showed that there was a big difference (about 25,000accidents/year) in the number of accidents occurred between right before the morning rush hour and right after the afternoon rush hour in 2000, but also a considerable reduction of difference (about 19,000accidents/year) in the number of accidents occurred between right before the morning rush hour and right after the afternoon rush hour in 2004. Particularly, the number of accidents occurred right before the morning rush hour (4 o'clock to 6 o'clock in the morning) showed the lowest values (about 10,600 accidents/year in 2000 and about 8,400accidents/year in 2004), while the number of accidents occurred right after the afternoon rush hour (6 o'clock to 8 o'clock in the afternoon) did the highest ones (about 35,600 accidents/year in 2000 and about 27,400accidents/year in 2004) as shown in Fig. 2.2. That is, the hourly factor characteristics were identified by accident analysis which has shown almost a similar accident occurrence pattern for the last 5 years regardless of the year.

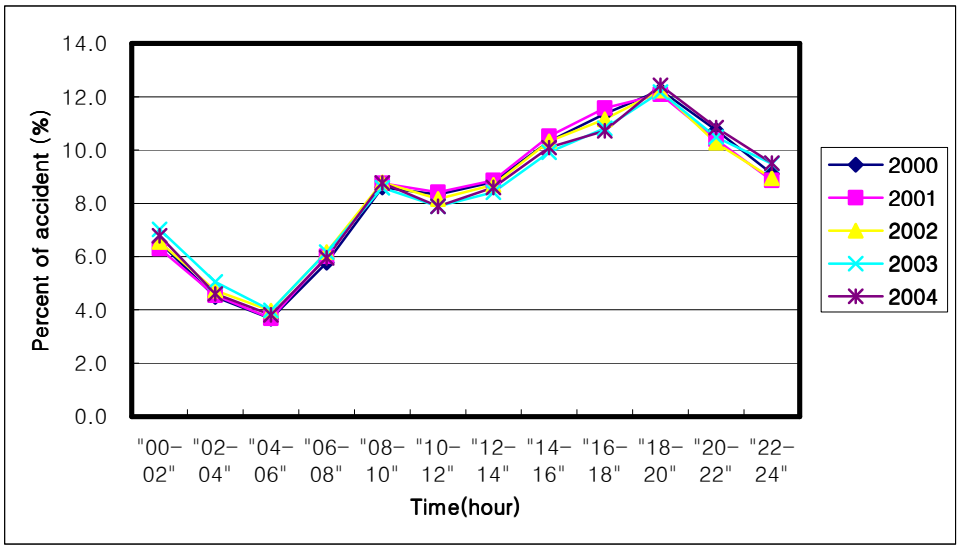

Fig. 2.2 POA patterns by hourly factor characteristics

On the other hand, compared with the percent of accident (POA) in the morning and afternoon periods of a whole day for the last 5 years, the results showed that there was no variation in the yearly percent of accident for each two-hour period as shown in Fig. 2.2. However, there was a big difference (about 8.5%) in the percent of accident between

right before the morning rush hour and right after the afternoon rush hour in 2000, and also a similar difference (about 8.6%) in the percent of accident between right before the morning rush hour and right after the afternoon rush hour in 2004.

Particularly, the POAs right before the morning rush hour (4 o'clock to 6 o'clock in the morning) showed the lowest values (about 3.7% in 2000 and about 3.8 in 2004), while the POAs right after the afternoon rush hour (6 o'clock to 8 o'clock in the afternoon) did the highest ones (about 12.2% in 2000 and about 12.4 in 2004) as shown in Fig. 2.2 and Table 2.1. That is, the hourly factor characteristics were also identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of accidents.

Table 2.1 POA results before and after the rush hours

Year	POA Right before Morning RH (%)	POA Right after Afternoon RH (%)
2000	3.7%	12.2%
2001	3.7%	12.1%
2002	4.0%	12.2%
2003	4.0%	12.2%
2004	3.8%	12.4%

As a result, the hourly factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reduction. Thus, the transportation policies including the staggered work hour or reversible lane programs were required for reducing the need to travel and improving the safety to travel around the rush hours.

2.1.2 Accident analysis by day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred during the daytime and nighttime periods of a whole day for the last 5 years of 2000 to 2004. The number of accidents occurred in the nighttime periods (6 o'clock in the afternoon to 6 o'clock in the morning) as well as the daytime periods (6 o'clock in the morning to 6 o'clock in the afternoon) have gradually decreased since 2000, except for 2003. Also, the number of accidents occurred in the daytime periods were shown to be much more than those in the nighttime periods by shaping the 3-dimensional polynomial shift curves for the last 5 years, as shown in Fig. 2.3.

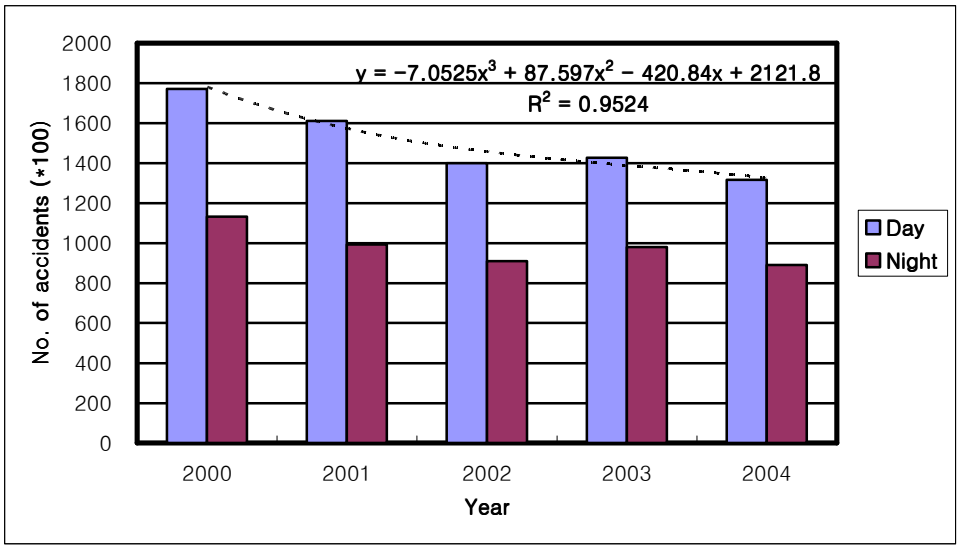

Fig. 2.3 Accident patterns by day-and-night factor characteristics

On the one hand, compared with the number of accidents occurred in the daytime period and nighttime period of a whole for the last 5 years, the results showed that there was a big difference (about 63,900 accidents/year) in the number of accidents occurred between the daytime and nighttime periods in 2000, but also a considerable reduced difference (about 42,500accidents/year) in the number of accidents occurred between the daytime and nighttime periods in 2004. Particularly, the number of accidents occurred in the daytime periods showed the highest values (about 177,000 accidents/year in 2000 and about 132,000accidents/year in 2004), while the number of accidents occurred in the nighttime periods did the lowest ones (about 113,000 accidents/year in 2000 and about 89,000accidents/year in 2004) as shown in Fig. 2.3. That is, the day-and-night factor characteristics was identified by accident analysis which has shown almost a similar accident occurrence pattern for the last 5 years regardless of the year, even though there was a considerable change in the number of accidents.

On the other hand, compared with the percent of accident (POA) in the daytime and nighttime periods of a whole day for the last 5 years, the results showed that there was a big difference in the percent of accident between the daytime and nighttime periods for the last 5 years as shown in Fig. 2.4. Particularly, there was a big difference (about 22%) in the percent of accident between the daytime and nighttime periods in 2000, and also a similar difference (about 20%) in the percent of accident between the daytime and nighttime periods in 2004. Additionally, the POAs in the daytime periods (6 o'clock in the morning to 6 o'clock in the afternoon) showed the highest values (about 61% in 2000 and about 39% in 2000), while the POAs in the nighttime periods (6 o'clock in the afternoon to 6 o'clock in the morning) did the lowest ones (about 60% in 2000 and about

40% in 2004) as shown in Fig. 2.4 and Table 2.2. That is, the day-and-night factor characteristics were also identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of accident.

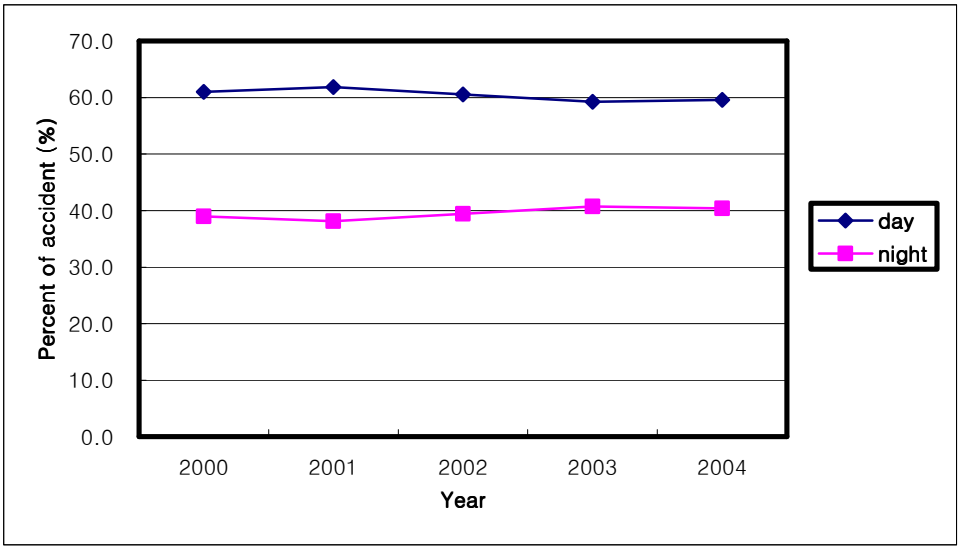

Fig. 2.4 POA patterns by day-and-night factor characteristics

Table 2.2 POA results by day-and-night factor characteristics

Year	POA in the daytime period (%)	POA in the nighttime period (%)
2000	61.0%	39.0%
2001	61.9%	38.9%
2002	60.6%	39.4%
2003	59.3%	40.7%
2004	59.6%	40.4%

As a result, the day-and-night factor characteristics showed that traffic accidents were shaped by the 3-D polynomial shift patterns. Thus, the transportation policies including the staggered work hour or reduced business travel programs were required for reducing the need to travel and improving the safety to travel during the daytime period.

2.1.3 Accident analysis by weekday factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred every weekday of a whole week for the last 5 years of 2000 to 2004. The number of accidents occurred during the weekdays have gradually decreased since 2000, except for 2003. Also, the number of accidents occurred during the day before

weekend were shown to be remarkably more than those occurred during the rest of the weekdays by shaping the 3-dimensional polynomial shift curves for the last 5 years, as shown in Fig. 2.5. Additionally, the number of accidents occurred during the day before weekend (Saturday) of a whole week were shown to be high, but those occurred during the rest of the weekdays of a whole week shown to be low throughout the last 5 years, as shown in Fig. 2.5.

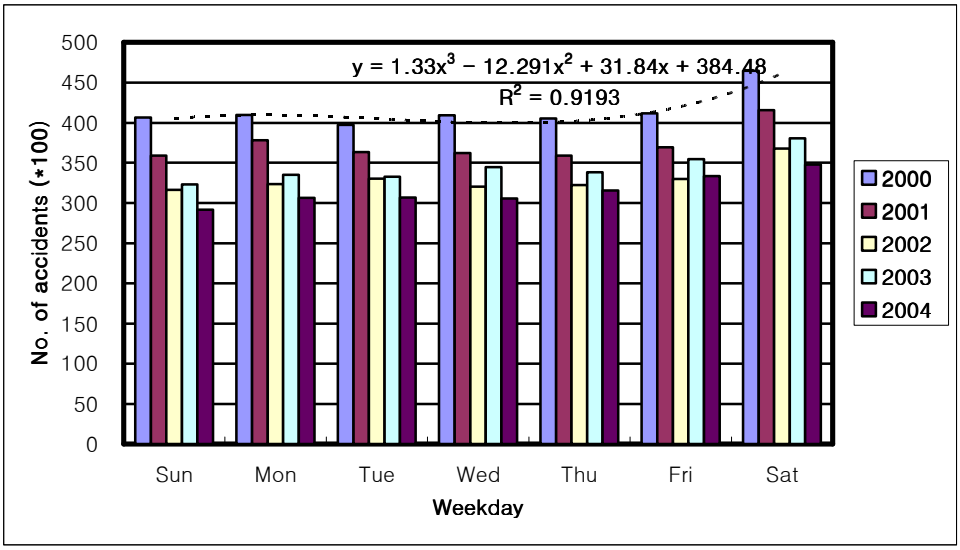

Fig. 2.5 Accident patterns by weekday factor characteristics

On the one hand, compared with the number of accidents occurred during the day before weekend (Saturday) and the rest of the weekdays of a whole week for the last 5 years, the results showed there was a considerable big difference (about 5,300accidents/year to about 6,700accidents/year) in the number of accidents occurred between the day before weekend (Saturday) and the rest of the weekdays of a whole week in 2000, but a little reduced difference (about 1,400accidents/year to about 5,600accidents/year)in the number of accidents occurred between the day before weekend (Saturday) and the rest of the weekdays of a whole week in 2004. Particularly, the number of accidents occurred during the day before weekend (Saturday) showed the high values (about 46,000accidents/year in 2000 and about 35,000accidents/year in 2004), while the number of accidents occurred during the rest of the weekdays did the low ones (about 41,000accidents/year in 2000 and about 29,000accidents/year in 2004), as shown in Fig. 2.5. That is, the weekday factor characteristics were identified by accident analysis which has shown almost a similar accident occurrence pattern for the last 5 years regardless of the year.

On the other hand, compared with the percent of accident during the day before weekend

(Saturday) and the rest of the weekdays of a whole week for the last 5 years, the results showed there was a considerable difference (about 14% to about 16%) in the percent of accident between the day before weekend (Saturday) and the rest of the weekdays of a whole week in 2000, and also a considerable difference (about 14% to about 16%)in the percent of accident between the day before weekend (Saturday) and the rest of the weekdays of a whole week in 2004. Particularly, the percent of accident during the day before weekend (Saturday) showed the high values (about 16% in 2000 and about 16% in 2004), while the percent of accident during the rest of the weekdays did the low ones (about 14% in 2000 and about 13% in 2004), as shown in Fig. 2.6 and Table 2.3. That is, the weekday factor characteristics were also identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of accidents.

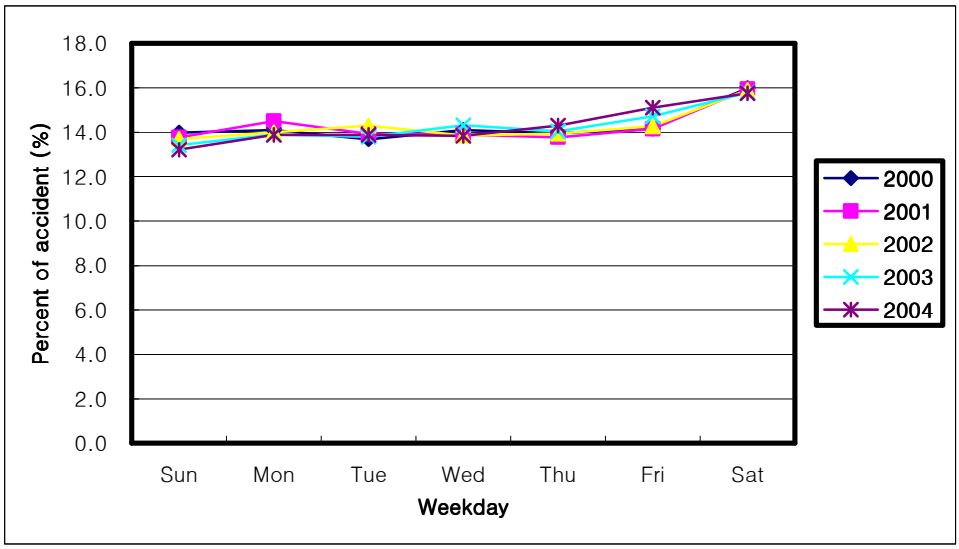

Fig. 2.6 POA patterns by weekday factor characteristics

As a result, the weekday factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the five day work week or communication substitutes programs were required for reducing the need to travel and improving the safety to travel during the day before and after Sunday.

Table 2.3 POA results by weekday factor characteristics

Year	Sun	Mon	Tue	Wed	Thu	Fri	Sat
2000	14.0%	14.1%	13.7%	14.1%	14.0%	14.2%	16.0%
2001	13.8%	14.5%	13.9%	13.9%	13.8%	14.2%	15.9%
2002	13.7%	14.0%	14.3%	13.9%	13.9%	14.3%	15.9%

2003	13.4%	13.9%	13.8%	14.3%	14.0%	14.7%	15.8%
2004	13.2%	13.9%	13.9%	13.9%	14.3%	15.1%	15.8%

2.1.4 Accident analysis by monthly factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred every month of a whole year for the last 5 years of 2000 to 2004. The number of accidents has gradually decreased during every month since 2000, except for 2003. Also, the number of accidents occurred in May was shown to be more than those occurred in the rest of the months by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.7. In addition, the number of accidents occurred during May of a whole year were shown to be high, but those occurred during the rest of the months of a whole year shown to be low throughout the last 5 years, as shown in Fig. 2.7.

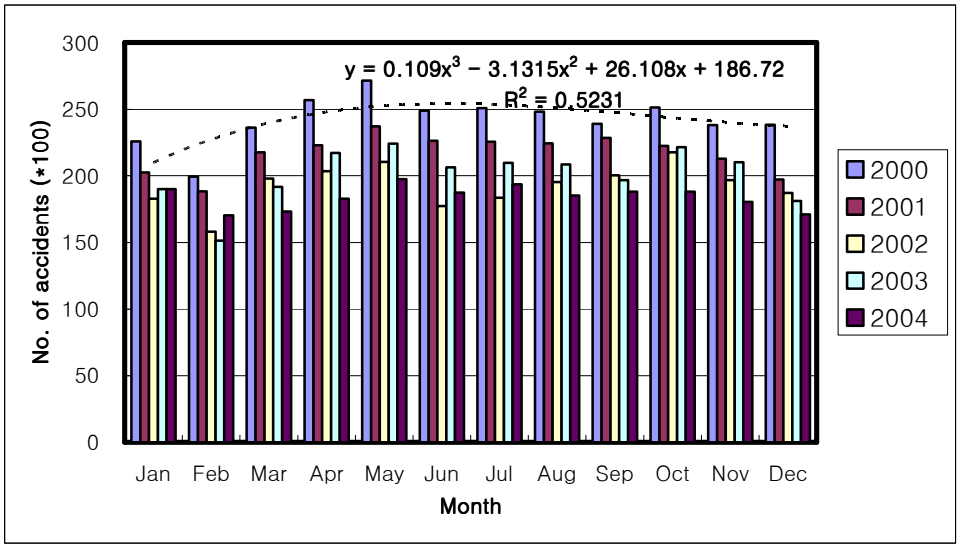

Fig. 2.7 Accident pattern by monthly factor characteristics

On the one hand, compared with the number of accidents occurred during May and the rest of the months of a whole year for the last 5 years, the results showed there was a considerable big difference (about 1,500accidents/year to about 4,500accidents/year) in the number of accidents occurred between May and the rest of the months of a whole year in 2000, but a little reduced difference (about 400accidents/year to about 2,700accidents/year) in the number of accidents occurred between May and the rest of the months of a whole year in 2004. Particularly, the number of accidents occurred during May showed the high values (about 27,000accidents/year in 2000 and about 20,000accidents/year in 2004), while the number of accidents occurred during the rest of the months did the low ones (about 20,000accidents/year to 25,000000accidents/year in

2000 and about 17,000accidents/year to 19,000accidents/year in 2004), as shown in Fig. 2.7. That is, the monthly factor characteristics were identified by accident analysis which has shown almost a similar accident occurrence pattern for the last 5 years regardless of the year.

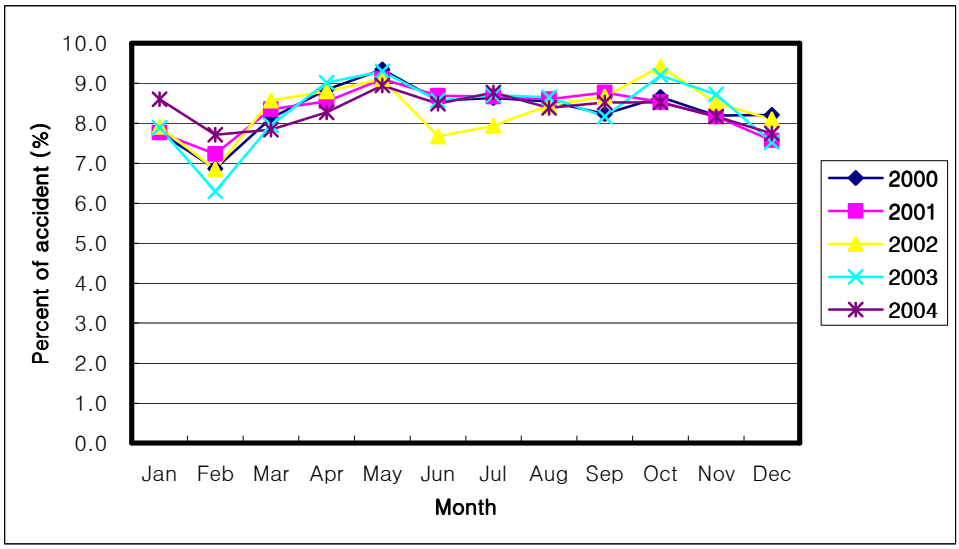

Fig. 2.8 POA pattern by monthly factor characteristics

On the other hand, compared with the percent of accident during May and the rest of the months of a whole year for the last 5 years, the results showed there was a considerable difference (about 0.5% to about 2.4%) in the percent of accident between May and the rest of the months of a whole year in 2000, and also a considerable difference (about 0.1% to about 1.2%)in the percent of accident between May and the rest of the months of a whole year in 2004. Particularly, the percent of accident during May showed the high values (about 9.3% in 2000 and about 8.9% in 2004), while the percent of accident during the rest of the months did the low ones (about 6.9% in 2000 and about 7.7% in 2004), as shown in Fig. 2.8 and Table 2.4. That is, the monthly factor characteristics were also identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of accidents.

Table 2.4 POA results by monthly factor characteristics

Mon	2000	2001	2002	2003	2004
Jan	7.8%	7.8%	7.9%	7.9%	8.6%
Feb	6.9%	7.2%	6.8%	6.3%	7.7%
Mar	8.1%	8.4%	8.6%	8.0%	7.8%
Apr	8.8%	8.5%	8.8%	9.0%	8.3%

May	9.3%	9.1%	9.1%	9.3%	8.9%
Jun	8.6%	8.7%	7.7%	8.6%	8.5%
Jul	8.6%	8.7%	7.9%	8.7%	8.8%
Aug	8.5%	8.6%	8.5%	8.7%	8.4%
Sep	8.2%	8.8%	8.7%	8.2%	8.5%
Oct	8.7%	8.5%	9.4%	9.2%	8.5%
Nov	8.2%	8.2%	8.5%	8.7%	8.2%
Dec	8.2%	7.6%	8.1%	7.5%	7.7%

As a result, the monthly factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reduction. Thus, the transportation policies including the five day work week or reduced business travel programs were required for reducing the need to travel and improving the safety to travel during the months of May and October.

2.1.5 Accident analysis by seasonal factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred every season of a whole year for the last 5 years of 2000 to 2004. The number of accidents has gradually decreased each season since 2000, except for 2003. Also, the number of accidents occurred in spring and summer was shown to be more than that occurred in autumn and winter by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.9. In addition, the number of accidents occurred during the winter season of a whole year were shown to be low, but that occurred during the rest of the seasons of a whole year shown to be high throughout the last 5 years, as shown in Fig. 2.9.

On the one hand, compared with the number of accidents occurred during the winter season and the rest of the seasons of a whole year for the last 5 years, the results showed there was a considerable big difference (about 6,500accidents/year to about 10,100accidents/year) in the number of accidents occurred between the winter season and the rest of the seasons of a whole year in 2000, but a little reduced difference (about 2,200accidents/year to about 3,500accidents/year) in the number of accidents occurred between the winter season and the rest of the seasons of a whole year in 2004.

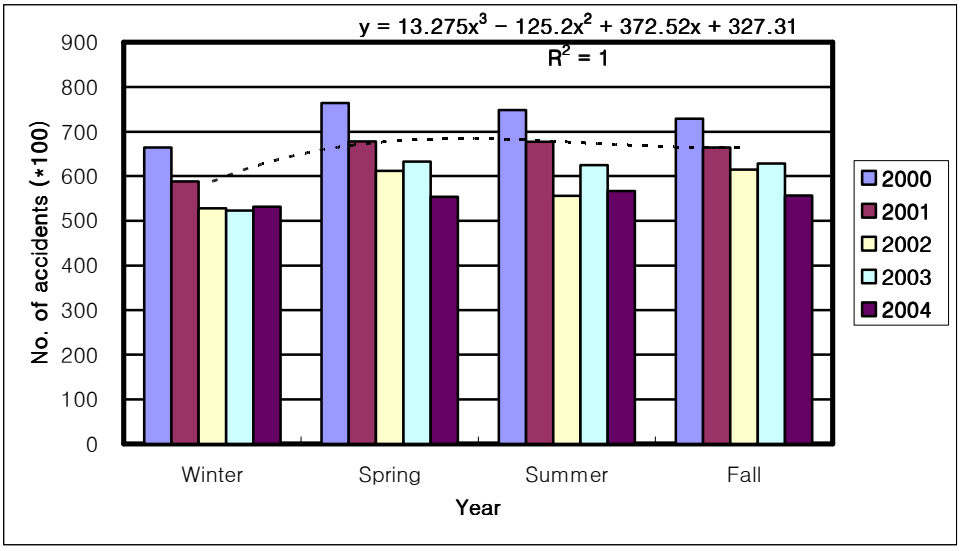

Fig. 2.9 Accident patterns by seasonal factor characteristics

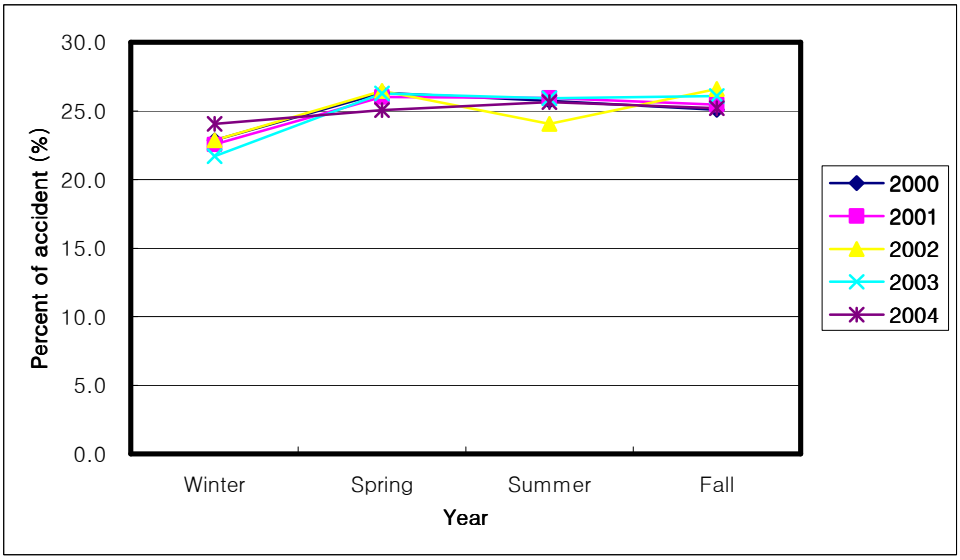

Fig. 2.10 POA patterns by seasonal factor characteristics

Particularly, the number of accidents occurred during the winter season showed the low values (about 66,000accidents/year in 2000 and about 53,000accidents/year in 2004), while the number of accidents occurred during the rest of the seasons did the low ones (about 73,000accidents/year in 2000 and about 55,000accidents/year in 2004), as shown in Fig. 2.9. That is, the seasonal factor characteristics were identified by accident analysis which has shown almost the similar accident occurrence pattern for the last 5 years regardless of the year.

On the other hand, compared with the percent of accident during the winter season and the rest of the seasons of a whole year for the last 5 years, the results showed there was a little difference (about 2.3% to about 3.5%) in the percent of accident between the winter

season and the rest of the seasons of a whole year in 2000, and also a little reduced difference (about 1.0% to about 1.6%) in the percent of accident between the winter season and the rest of the seasons of a whole year in 2004. Particularly, the percent of accident during the winter season showed the low values (about 22.8% in 2000 and about 24.1% in 2004), while the percent of accident during the rest of the seasons did the high ones (about 26.3% in 2000 and about 25.7% in 2004), as shown in Fig. 2.10 and Table. 2.5. That is, the seasonal factor characteristics were identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of accidents.

Table 2.5 POA results by seasonal factor characteristics

Year	Winter	Spring	Summer	Fall
2000	22.8%	26.3%	25.8%	25.1%
2001	22.6%	26.0%	26.0%	25.5%
2002	22.9%	26.5%	24.1%	26.6%
2003	21.7%	26.3%	25.9%	26.1%
2004	24.1%	25.1%	25.7%	25.2%

As a result, the seasonal factor characteristics showed that traffic accidents were shaped by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the five day work week or communication substitutes programs were required for reducing the need to travel and improving the safety to travel during the spring season.

2.2 Accident Analysis by the Non-periodic Factor Characteristics

2.2.1 Accident analysis by regional factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred in most of the regions for the last 5 years of 2000 to 2004. The number of accidents occurred in most of the regions has gradually decreased 2004 since 2000, except for 2003. Also, the number of accidents occurred in Seoul and Kyonggi regions (called Capital Region) was shown to be more than that occurred in the rest of the regions, as shown in Fig. 2.11. Additionally, the number of accidents occurred in the Capital Region were shown to be very high, but those occurred in the rest of the regions shown to be low throughout the last 5 years, as shown in Fig. 2.11.

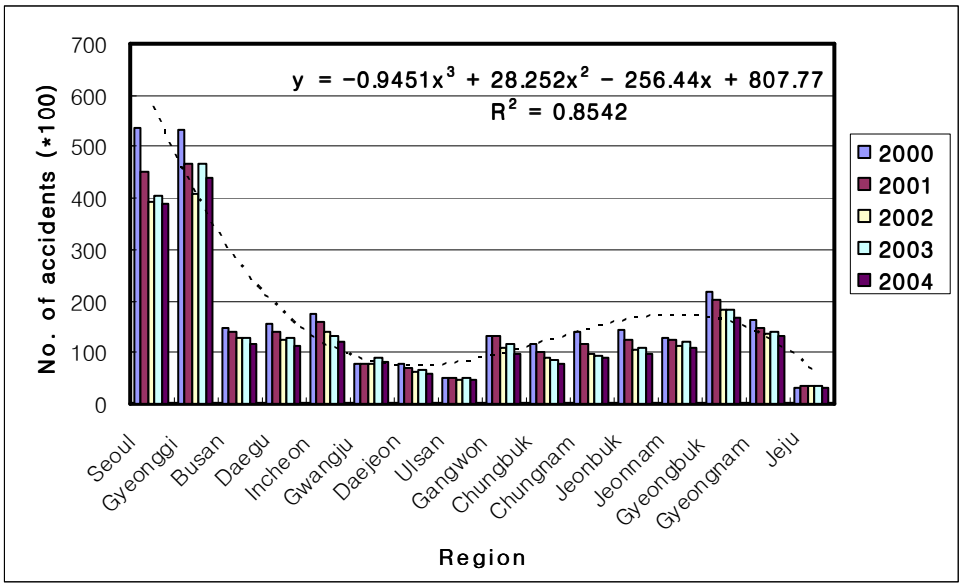

Fig. 2.11 Accident patterns by regional factor characteristics

On the one hand, compared with the number of accidents occurred in the Capital Region and the rest of the regions for the last 5 years, the results showed there was a big difference (about 32,000accidents/year to about 51,000accidents/year) in the number of accidents occurred between the Capital Region and the rest of the regions in 2000, and a little reduced difference (about 27,000accidents/year to about 41,000accidents/year) in the number of accidents occurred between the Capital Region and the rest of the regions in 2004. Particularly, the number of accidents occurred in the Capital Region showed the high values (about 54,000accidents/year in 2000 and about 44,000accidents/year in 2004), while the number of accidents occurred in the rest of the regions did the low ones (about 3,000accidents/year in 2000 and about 3,000accidents/year in 2004), as shown in Fig. 2.11. That is, the regional factor characteristics were identified by accident analysis which has shown almost the same accident occurrence pattern for the last 5 years

regardless of the year.

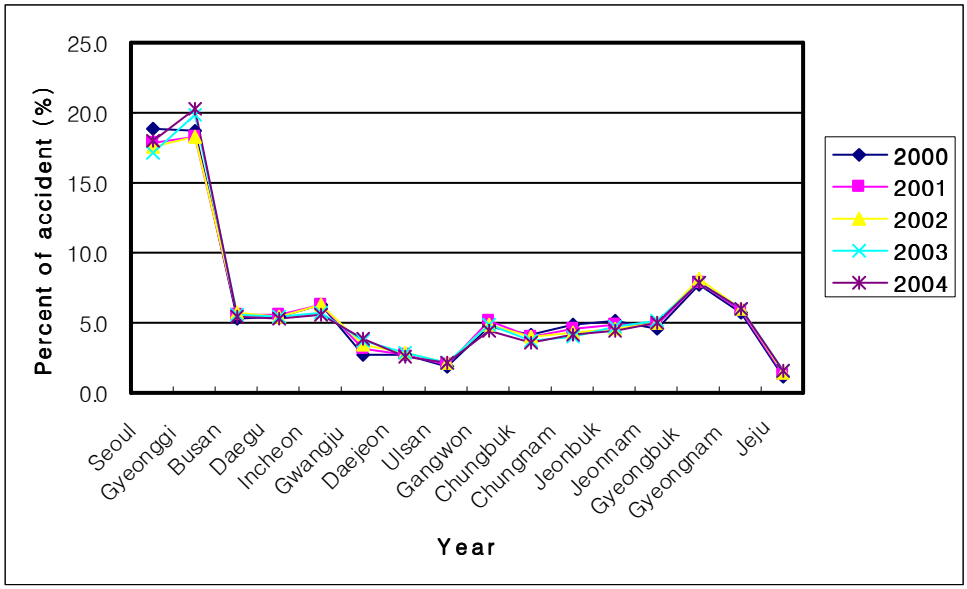

Fig. 2.12 POA patterns by regional factor characteristics

Table 2.6 POA results by regional factor characteristics

Region	2000	2001	2002	2003	2004
Seoul	18.9%	17.8%	17.6%	17.1%	17.9%
Gyeonggi	18.8%	18.3%	18.3%	19.8%	20.3%
Daegu	5.5%	5.5%	5.5%	5.5%	5.2%
Incheon	6.2%	6.3%	6.3%	5.7%	5.5%
Gwangju	2.8%	3.1%	3.4%	3.7%	3.8%
Daejeon	2.7%	2.7%	2.8%	2.9%	2.6%
Ulsan	1.8%	2.0%	2.1%	2.1%	2.1%
Busan	5.3%	5.6%	5.7%	5.5%	5.4%
Gangwon	4.7%	5.2%	4.9%	4.9%	4.5%
Chungbuk	4.2%	4.0%	3.9%	3.7%	3.6%
Chungnam	4.9%	4.6%	4.3%	4.0%	4.2%
Jeonbuk	5.1%	4.9%	4.6%	4.7%	4.4%
Jeonnam	4.6%	4.9%	5.0%	5.1%	5.1%
Gyeongbuk	7.8%	7.9%	8.1%	7.8%	7.8%
Gyeongnam	5.7%	5.9%	6.0%	6.0%	6.1%
Jeju	1.1%	1.3%	1.5%	1.5%	1.5%

On the other hand, compared with the percent of accident in the Capital Region and the rest of the regions for the last 5 years, the results showed there was a big difference (about 11% to about 18%) in the percent of accident between the Capital Region and the

rest of the regions in 2000, and also a little reduced difference (about 13% to about 19%) in the percent of accident between the Capital Region and the rest of the regions in 2004. Particularly, the percent of accident in the Capital Region showed the high values (about 19% in 2000 and about 20% in 2004), while the percent of accident in the rest of the regions did the low ones (about 1.1% in 2000 and about 1.5% in 2004), as shown in Fig. 2.12 and Table 2.6. That is, the regional factor characteristics were also identified by the POA analysis which has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a big change in the number of accidents.

As a result, the regional factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the zoning/area type control or communication substitute programs were required for reducing the need to travel and improving the safety to travel within the Capital Region.

2.2.2 Accident analysis by location factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred in the specific locations for the last 5 years of 2000 to 2004.

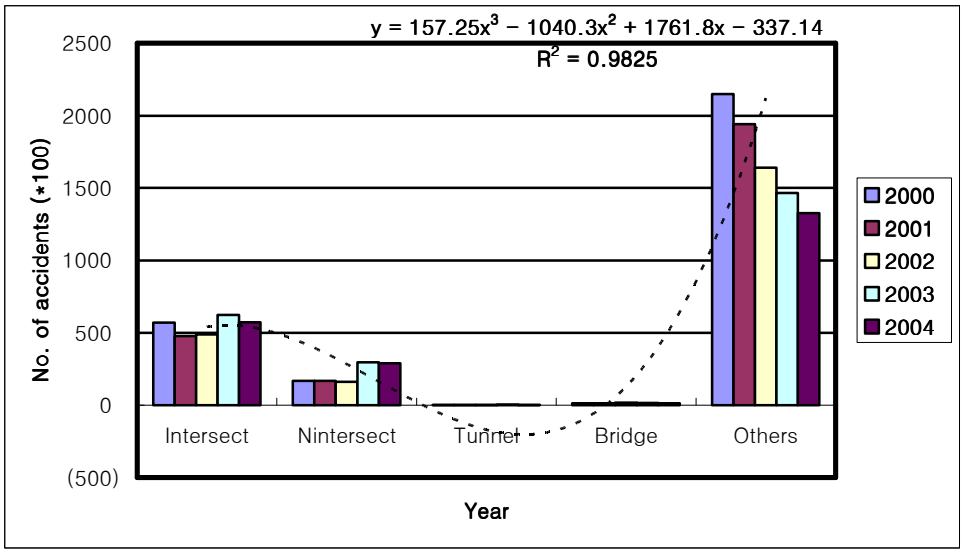

Fig. 2.13 Accident patterns by location factor characteristics

The number of accidents occurred in the other locations have gradually decreased since 2000, except for the specific locations. Also, the number of accidents occurred in the other locations was shown to be more than that occurred in the specific locations (intersection, near-intersection, tunnel, and bridge) by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.13. Additionally, the number of accidents

occurred in the other locations were shown to be very high, but those occurred in the specific locations shown to be low throughout the last 5 years, as shown in Fig. 2.13.

On the one hand, compared with the number of accidents occurred in the specific locations and the other locations for the last 5 years, the results showed there was a big difference (about 139,000accidents/year) in the number of accidents occurred between the specific locations and the other locations in 2000, but a little reduced difference (about 45,000accidents/year) in the number of accidents occurred between the specific locations and the other locations in 2004. Particularly, the number of accidents occurred in the specific locations showed the low values (about 76,000accidents/year in 2000 and about 88,000accidents/year in 2004), while the number of accidents occurred in the other locations did the high ones (about 215,000accidents/year in 2000 and about 133,000accidents/year in 2004), as shown in Fig. 2.7. That is, the location factor characteristics were identified by accident analysis which has shown the lower accident occurrence pattern in the specific locations than in the other locations for the last 5 years regardless of the year.

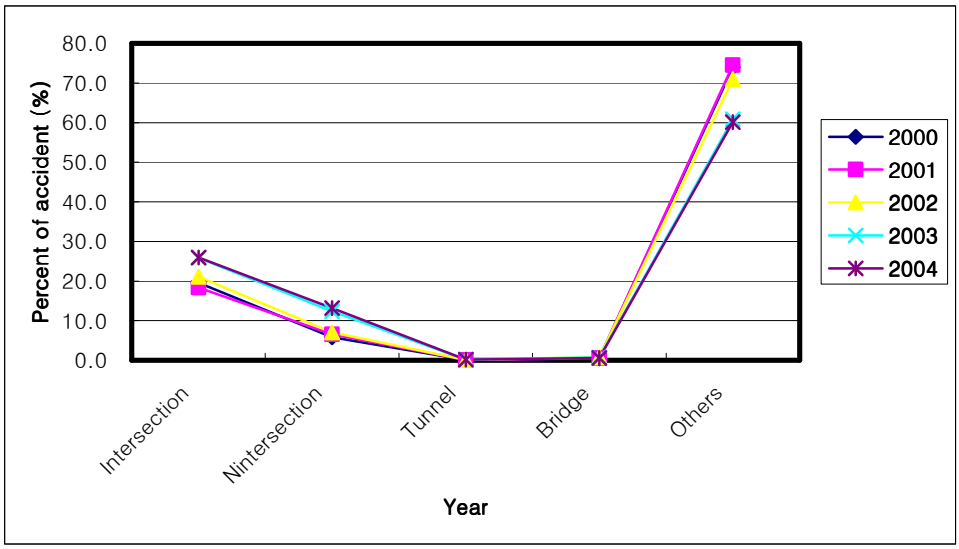

Fig. 2.14 POA patterns by location factor characteristics

On the other hand, compared with the percent of accident in the specific locations and the other locations for the last 5 years, the results showed there was a big difference (about 48%) in the percent of accident between the specific locations and the other locations in 2000, and also a little reduced difference (about 20%) in the percent of accident between the specific locations and the other locations in 2004. Particularly, the percent of accident in the specific locations showed the low value (about 26% in 2000 and about 40% in 2004), while the percent of accident in the other locations did the high

ones (about 74% in 2000 and about 60% in 2004), as shown in Fig. 2.14 and Table 2.7. That is, the location factor characteristics were also identified by the POA analysis which has shown the higher percent of accident in the other locations than in the specific locations for the last 5 years regardless of the year.

Table 2.7 POA results by location factor characteristics

Year	Intersection	Near intersection	Tunnel	Bridge	Others
2000	19.6%	5.8%	0.1%	0.5%	74.0%
2001	18.3%	6.5%	0.1%	0.5%	74.5%
2002	21.1%	7.0%	0.1%	0.8%	71.0%
2003	25.9%	12.3%	0.2%	0.7%	60.9%
2004	25.9%	13.2%	0.2%	0.6%	60.1%

As a result, the location factor characteristics showed that traffic accidents were shaped by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the improved signal systems or redesigning intersection programs were required for reducing the need to travel and improving the safety to travel at the specific locations.

2.2.3 Accident analysis by road type factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred on the road of types for the last 5 years of 2000 to 2004. The number of accidents occurred on the road of types has gradually decreased since 2000. Also, the number of accidents occurred on the national highway was shown to be more than those occurred on the other roads (national expressway or provincial road) by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.15. Additionally, the number of accidents occurred on the national highway were shown to be very high, but those occurred on the national expressway or provincial road shown to be very low throughout the last 5 years, as shown in Fig. 2.15.

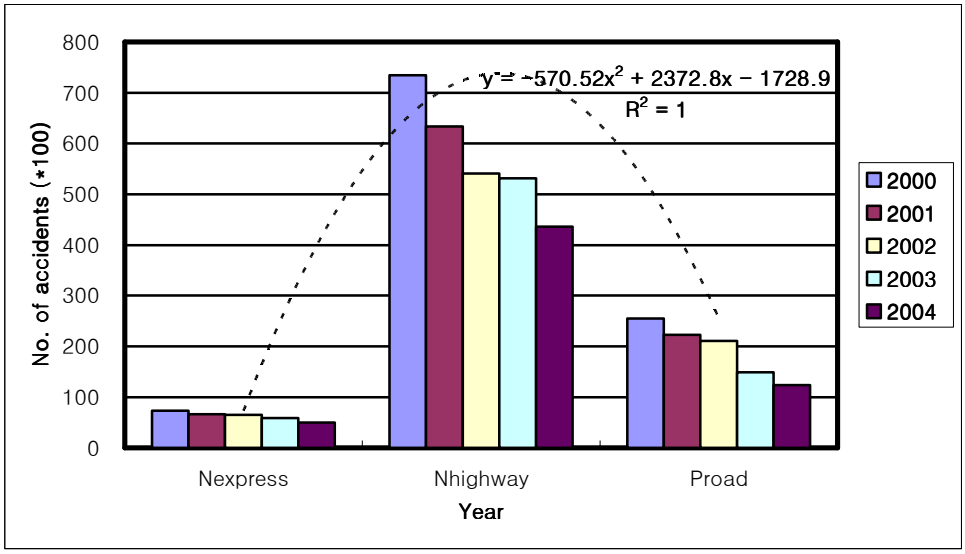

Fig. 2.15 Accident patterns by road type factor characteristics

On the one hand, compared with the number of accidents occurred on the national highway, national expressway and provincial road for the last 5 years, the results showed that there was a big difference (about 66,000accidents/year) in the number of accidents occurred between the national highway and national expressway in 2000, but a little big difference (about 39,000accidents/year) in the number of accidents occurred between the national highway and national expressway in 2004.

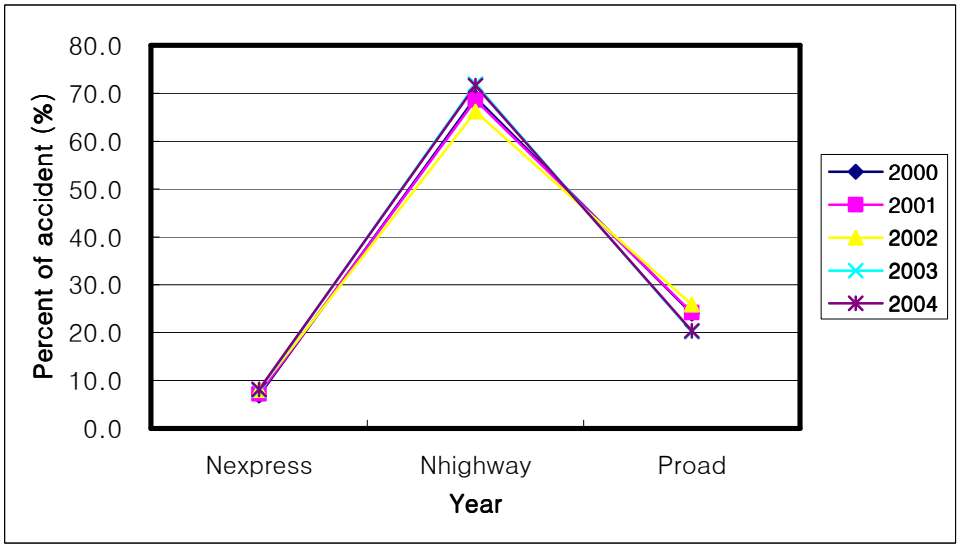

Fig. 2.16 POA patterns by road type factor characteristics

Also, the results were shown to be a big difference (about 48,000accidents/year) in the number of accidents occurred between the national highway and provincial road in 2000, and a little big difference (about 31,000accidents/year) in the number of accidents

occurred between the national highway and provincial road in 2004. Particularly, the number of accidents occurred on the national highway showed the high value (about 73,000accidents/year in 2000 and about 44,000accidents/year in 2004), while the number of accidents occurred on the provincial road and national expressway did the low ones (about 25,500accidents/year for the provincial road and about 7,600accidents/year for the national expressway in 2000, and about 12,400accidents/year for the provincial road and about 4,900accidents/year for the national expressway in 2004), as shown in Fig. 2.15. That is, the road type factor characteristics were identified by accident analysis which has shown the lower accident occurrence patterns on the national expressway and provincial road than on the national highway for the last 5 years regardless of the year.

On the other hand, compared with the percent of accident on the national highway and national expressway, and provincial road for the last 5 years, the results showed that there was a big difference (about 62%) in the percent of accident between the national highway and national expressway in 2000, and also a little bigger difference (about 64%) in the percent of accident between the national highway and national expressway in 2004. Particularly, the percent of accident on the national expressway and provincial road showed the low values (about 7% and about 24% in 2000, and about 8% and about 20% in 2004), while the percent of accident on the national highway did the high one (about 69% in 2000 and about 72% in 2004), as shown in Fig. 2.16 and Table 2.8. That is, the road type factor characteristics was also identified by the POA analysis which has shown the higher percent of accident on the national highway than on the national expressway and provincial road for the last 5 years regardless of the year.

Table 2.8 POA results by road type factor characteristics

Year	National expressway	National highway	Provincial road
2000	6.9%	69.1%	24.0%
2001	7.2%	68.6%	24.2%
2002	8.0%	66.2%	25.8%
2003	7.9%	71.9%	20.2%
2004	8.1%	71.6%	20.3%

As a result, the road type factor characteristics showed that traffic accidents were shaped by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the improved signal systems or ramp metering, freeway programs were required for reducing the need to travel and improving the safety to travel on the roads.

2.2.4 Accident analysis by area type factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred in the areas classified by area type for the last 5 years of 2000 to 2004. The number of accidents in the urban area has gradually decreased up to 2002 since 2000 and increased thereafter. However, the number of accidents in the suburban area has gradually decreased since 2000, except for 2003, and the number of accidents in the rural area has gradually decreased since 2000 as well. Also, the number of accidents in the suburban area was shown to be more than those in the urban area or the rural area for the last 5 years by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.17. Additionally, the number of accidents occurred in the suburban area were shown to be very high, but those occurred in the urban are or rural area shown to be low throughout the last 5 years, as shown in Fig. 2.17.

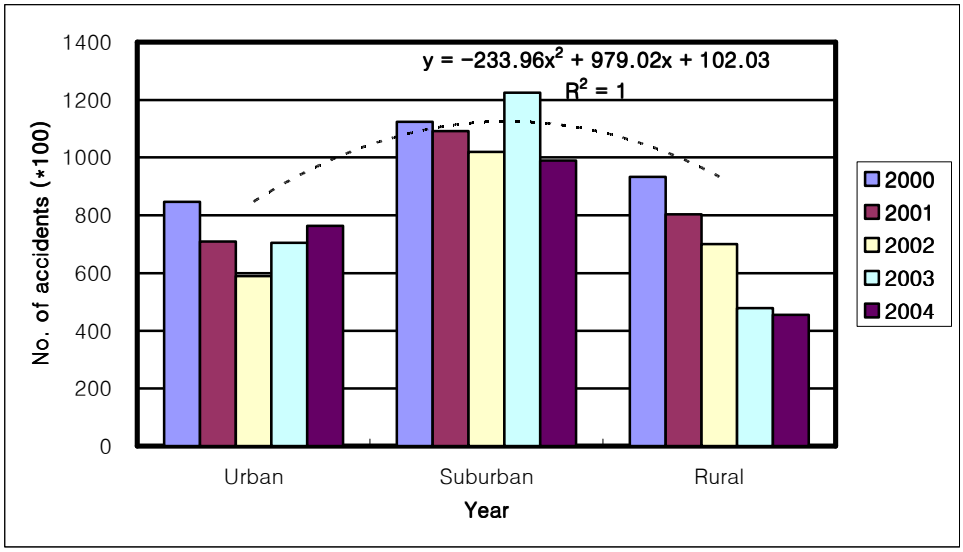

Fig. 2.17 Accident patterns by area type factor characteristics

On the one hand, compared with the number of accidents occurred in the suburban area, urban area, and rural area for the last 5 years, the results showed that there was a big difference (about 28,000accidents/year) in the number of accidents occurred between the suburban and urban areas in 2000, but a little big difference (about 23,000accidents/year) in the number of accidents occurred between the suburban and urban areas in 2004. Also, there was a big difference (about 19,000accidents/year) in the number of accidents occurred between the suburban and rural area in 2000, but a bigger difference (about 54,000accidents/year) in the number of accidents occurred between the suburban and rural areas in 2004. Particularly, the number of accidents occurred in the

suburban area showed the high values (about 112,000accidents/year in 2000 and about 99,000accidents/year in 2004), while the number of accidents occurred in the urban and rural areas did the low ones (about 85,000accidents/year for the urban area and about 93,000accidents/year for the rural area in 2000, respectively and about 76,000accidents/year for the urban area and about 46,000accidents/year for the rural area in 2004), as shown in Fig. 2.17. That is, the area type factor characteristics were identified by accident analysis which has shown the lower accident occurrence pattern in the urban and rural areas than the suburban area for the last 5 years regardless of the year.

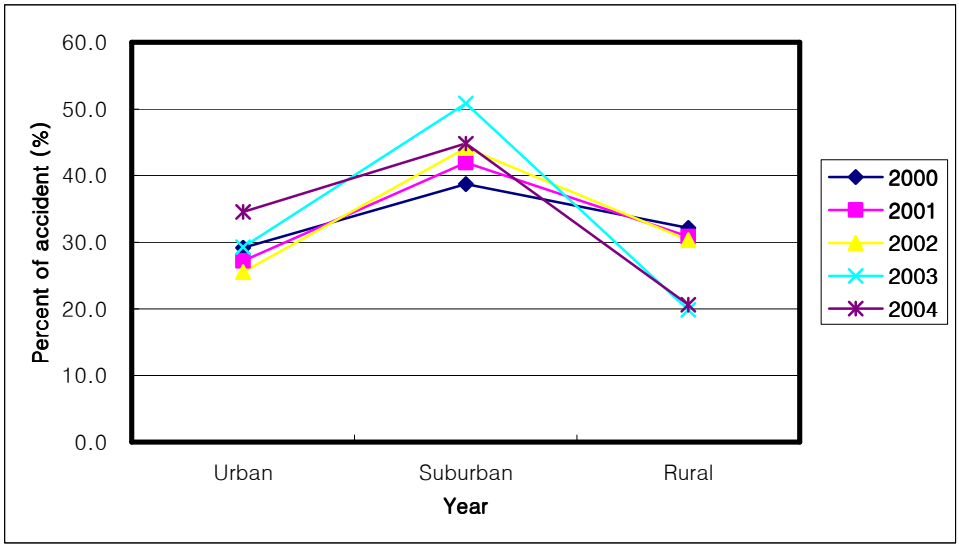

Fig. 2.18 POA patterns by area type factor characteristics

On the other hand, compared with the percent of accident in the suburban, urban, and rural areas for the last 5 years, the results showed there was a big difference (about 10%) in the percent of accident between the suburban and urban areas in 2000, and also a big difference (about 10%) in the percent of accident between the suburban and urban areas in 2004. Particularly, the percent of accident in the urban area showed the low value (about 29% in 2000 and about 34% in 2004), while the percent of accident in the suburban area did the high ones (about 39% in 2000 and about 45% in 2004), as shown in Fig. 2.18 and Table 2.9. Also, the percent of accident in the suburban area was shown to be much higher than that in the rural area (about 7% in 2000 and about 24% in 2004). That is, the area type factor characteristics were also identified by the POA analysis which has shown the high percent of accident in the suburban area and the low ones in the urban and rural areas for the last 5 years regardless of the year.

Table 2.9 POA results by area type factor characteristics

Year	Urban	Suburban	Rural

2000	29.2%	38.7%	32.1%
2001	27.2%	41.9%	30.9%
2002	25.5%	44.1%	30.3%
2003	29.3%	50.9%	19.9%
2004	34.6%	44.8%	20.6%

As a result, the road type factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the zoning/land use control or reduced business travel programs were required for reducing the need to travel and improving the safety to travel for the areas, especially the suburban area.

2.2.5 Accident analysis by the vehicle type factor characteristics

Accident analysis was conducted for making a characteristic comparison between traffic accidents occurred with the vehicles classified by vehicle types for the last 5 years of 2000 to 2004.

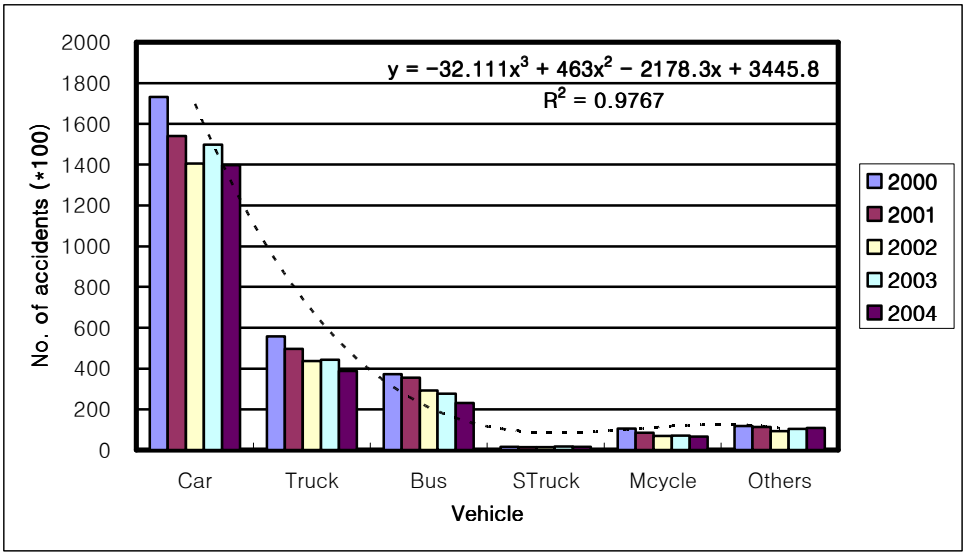

Fig. 2.19 Accident patterns by vehicle type factor characteristics

The number of accidents by the vehicle types has gradually decreased since 2000, except for 2003. However, the number of accidents by bus has gradually decreased since 2000, but the number of accidents by the other vehicle types has repeated the decrease and increase of traffic accidents since 2000. Also, the number of accidents occurred by passenger car was shown to be much more than those occurred by bus or truck for the last 5 years by shaping the 3-dimensional polynomial shift curves, as shown in Fig. 2.19. Additionally, the number of accidents occurred by passenger car were shown to be very

high, but those occurred by special truck shown to be low throughout the last 5 years, as shown in Fig. 2.19.

On the one hand, compared with the number of accidents occurred by passenger car, bus, and truck for the last 5 years, the results showed that there was a very big difference (about 118,000accidents/year) in the number of accidents occurred between the passenger car and truck in 2000, but a big difference (about 101,000accidents/year) in the number of accidents occurred between the passenger car and truck in 2004. Also, there was a big difference (about 19,000accidents/year) in the number of accidents occurred between the truck and bus in 2000, but a little big difference (about 16,000accidents/year) in the number of accidents occurred between the truck and bus in 2004.

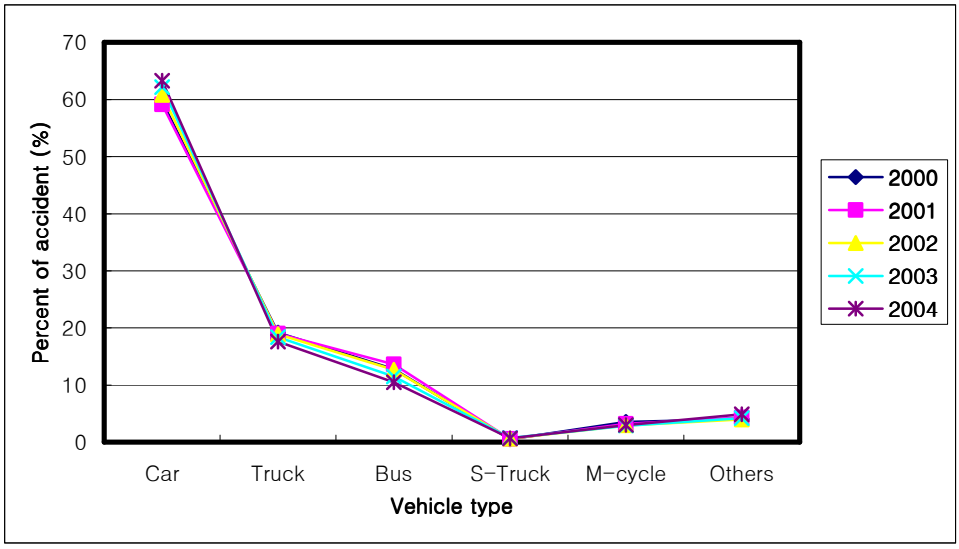

Fig. 2.20 POA patterns by vehicle type factor characteristics

Particularly, the number of accidents occurred by the passenger car showed the high values (about 173,000accidents/year in 2000 and about 140,000accidents/year in 2004), while the number of accidents occurred by truck and bus did the low ones (about 50,000accidents/year for the truck and about 36,000accidents/year for the bus in 2000, respectively and about 39,000accidents/year for the urban area and about 23,000accidents/year for the rural area in 2004), as shown in Fig. 2.19. That is, the vehicle type factor characteristics were identified by accident analysis which has shown the lower accident occurrence pattern by the truck and bus than the passenger car for the last 5 years regardless of the year.

On the other hand, compared with the percent of accident occurred by the passenger car, truck and bus for the last 5 years, the results showed that there was a big difference

(about 41%) in the percent of accident between the passenger car and truck in 2000, and also a big difference (about 45%) in the percent of accident between the passenger car and truck in 2004. Also, the results showed that there was a little big difference (about 6%) in the percent of accident between the truck and bus in 2000, and also a big difference (about 7%) in the percent of accident between the truck and bus in 2004. Particularly, the percent of accident occurred by the bus showed the low value (about 13% in 2000 and about 11% in 2004), while the percent of accident by the passenger car did the high ones (about 60% in 2000 and about 63% in 2004), as shown in Fig. 2.20 and Table 2.10. Also, the percent of accident by the passenger car was shown to be much higher than that by the bus (about 47% in 2000 and about 52% in 2004). That is, the vehicle type factor characteristics were also identified by the POA analysis which has shown the high percent of accident by the passenger car and the low ones by the truck and bus for the last 5 years regardless of the year.

Table 2.10 POA results by vehicle type factor characteristics

Year	Passenger car	Truck	Bus	Special Truck	Motorcycle
2000	60%	19%	13%	1%	4%
2001	59%	19%	14%	1%	3%
2002	61%	19%	13%	1%	3%
2003	62%	18%	11%	1%	3%
2004	63%	18%	11%	1%	3%

As a result, the vehicle type factor characteristics showed that traffic accidents were occurred by the 3-D polynomial shift patterns despite the accident reductions. Thus, the transportation policies including the limit hours/location of travel or reduced business travel programs were required for reducing the need to travel and improving the safety to travel for the vehicle types, especially the passenger car or truck.

2.3 Accident Analysis by the Cross Factor Characteristics

2.3.1 Accident analysis by month and day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between the monthly accidents occurred during the daytime and nighttime periods for the last 5 years of 2000 to 2004.

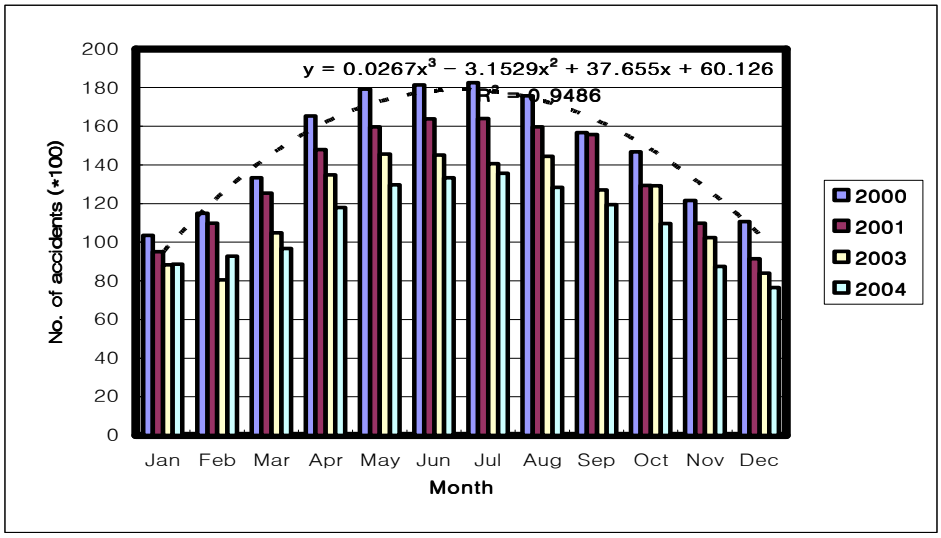

Fig. 2.21 Accident patterns by month and daytime factor characteristics

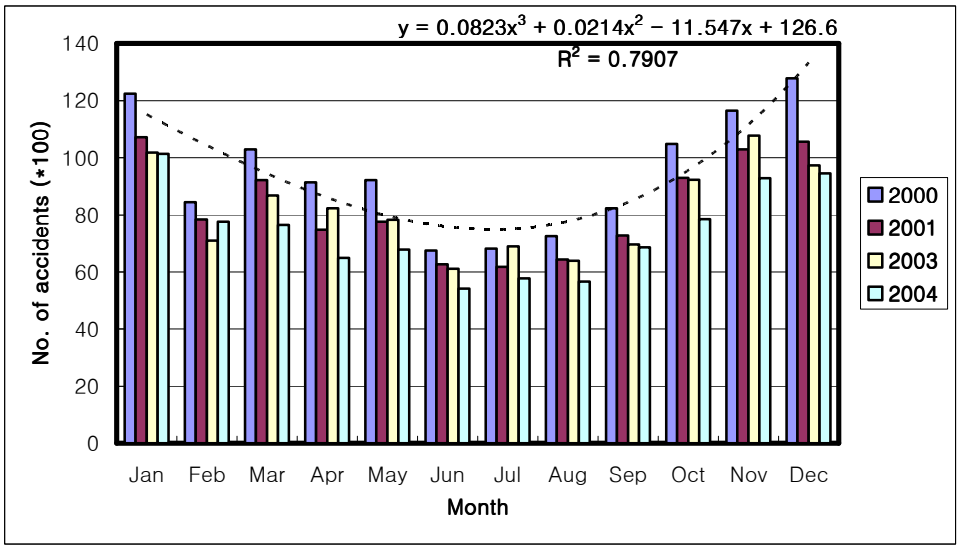

Fig. 2.22 Accident patterns by month and nighttime factor characteristics

The monthly accidents have gradually decreased since 2000. Additionally, the monthly accidents were shown to gradually increase from January till June, and decrease from July till December during the daytime periods as shown in Fig. 2.21. However, those accidents were shown to gradually decrease from January till June, and increase from

July till December during the nighttime periods as shown in Fig. 2.22.

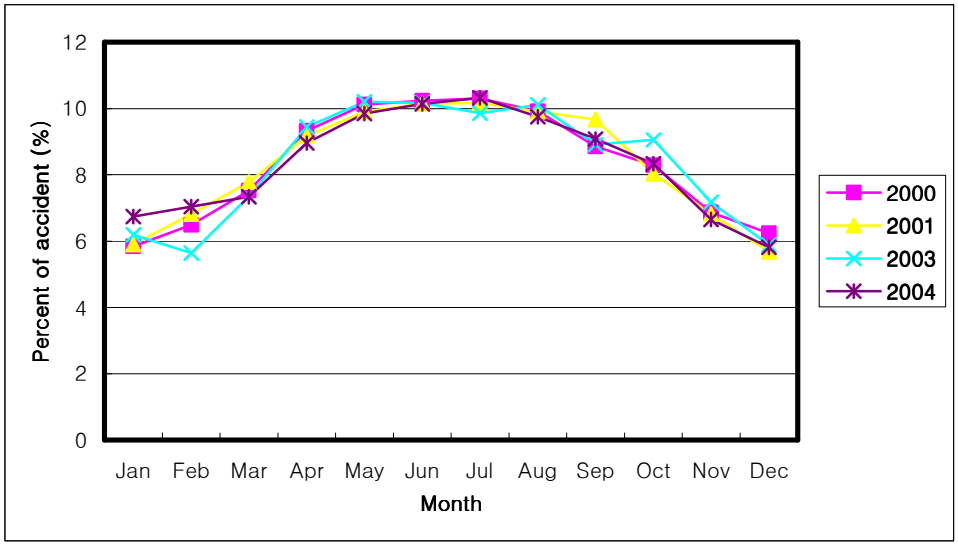

Fig. 2.23 POA patterns by month and daytime factor characteristics

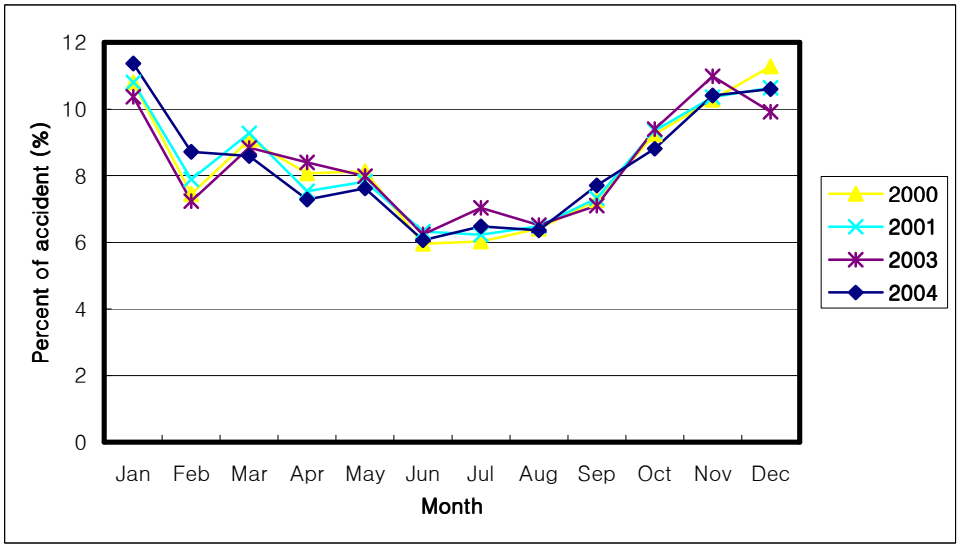

Fig. 2.24 POA patterns by month and nighttime factor characteristics

On the one hand, compared with the monthly accidents between the daytime and nighttime periods for the last 5 years, the results showed that there was a big difference (about 11,000accidents/month) in the monthly accidents during June and July in 2000, but also a little reduction of difference (about 7,000accidents/month) in 2004. Also, they shaped the 3-dimensional polynomial shift curves with a high explanatory power (R^2=0.9486 during the daytime period and R^2=0.7907 during the nighttime period). That is, the monthly accident analysis has shown almost the similar pattern characteristics for the last 5 years regardless of the year, even though there was a considerable change in

the monthly accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the monthly accident characteristics.

On the other hand, compared with the monthly percent of accident (POA) between the daytime and nighttime periods for the last 5 years, the results showed that there was a considerable difference (about 3% to 4%) in the monthly percent of accident during June and July in the monthly percent of accident as shown in Fig. 2.23 and 2.24, and Table 2.11. That is, the POA analysis has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the monthly accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the monthly accident characteristics.

Table 2.11 POA results by month and day-and-night factor characteristics

Year	2000		2001		2003		2004	
Month	Day	Night	Day	Night	Day	Night	Day	Night
Jan	5.8	10.8	5.9	10.8	6.2	10.4	6.7	11.4
Feb	6.5	7.4	6.8	7.9	5.6	7.2	7.0	8.7
Mar	7.5	9.1	7.8	9.3	7.4	8.8	7.3	8.6
Apr	9.3	8.1	9.2	7.5	9.5	8.4	9.0	7.3
May	10.1	8.1	9.9	7.8	10.2	8.0	9.9	7.6
Jun	10.2	6.0	10.2	6.3	10.2	6.2	10.1	6.1
Jul	10.3	6.0	10.2	6.2	9.9	7.0	10.3	6.5
Aug	9.9	6.4	9.9	6.5	10.1	6.5	9.8	6.4
Sep	8.8	7.3	9.7	7.3	8.9	7.1	9.1	7.7
Oct	8.3	9.2	8.0	9.4	9.1	9.4	8.3	8.8
Nov	6.9	10.3	6.8	10.4	7.2	11.0	6.7	10.4
Dec	6.2	11.3	5.7	10.6	5.9	9.9	5.8	10.6

As a result, the day-and-night factor characteristics became an important factor for identifying the monthly accident characteristics. Also, the accident related safety programs including the police enforcement were required for reducing the monthly accidents from April to September.

2.3.2 Accident analysis by season and day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between the seasonal accidents occurred during daytime and nighttime periods for the last 5 years of 2000 to 2004.

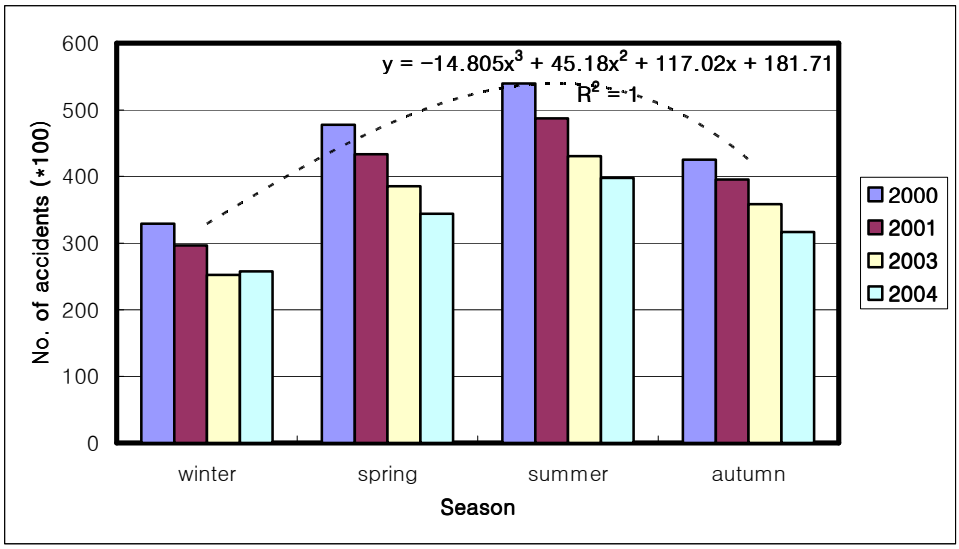

Fig. 2.25 Accident patterns by season and daytime factor characteristics

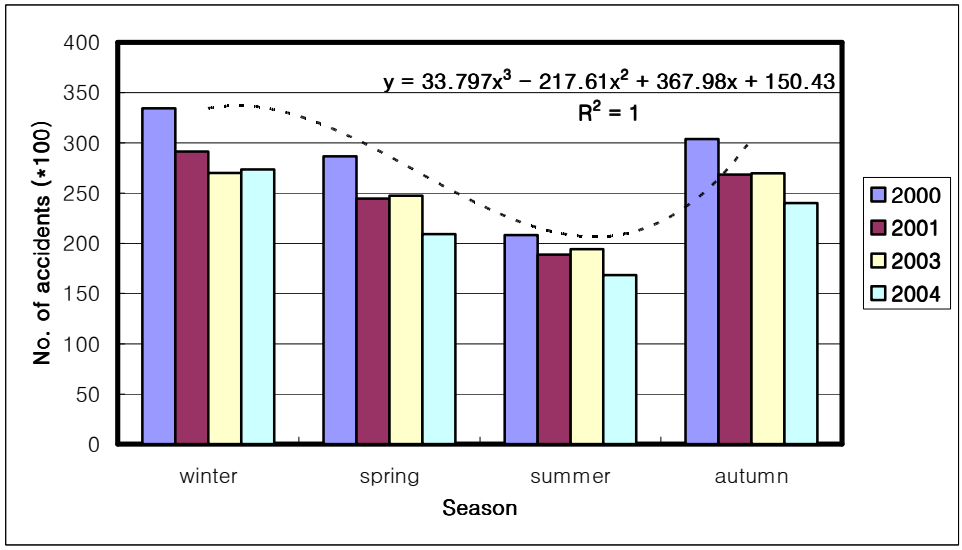

Fig. 2.26 Accident patterns by season and nighttime factor characteristics

The seasonal accidents have gradually decreased since 2000. Additionally, the seasonal accidents were shown to gradually increase from winter till summer, and decrease from summer till autumn during the daytime periods as shown in Fig. 2.25. However, those accidents were shown to gradually decrease from winter till summer, and increase from summer till autumn during the nighttime periods as shown in Fig. 2.26.

On the one hand, compared with the seasonal accidents between the daytime and nighttime periods for the last 5 years, the results showed that there was a big difference (about 33,000accidents/season) during the summer season in 2000, but also a little reduction of difference (about 23,000accidents/season) in 2004. Also, they shaped the 3-dimensional polynomial shift curves with the highest explanatory power (R^2=1.0 during

the daytime period and R^2=1.0 during the nighttime period).

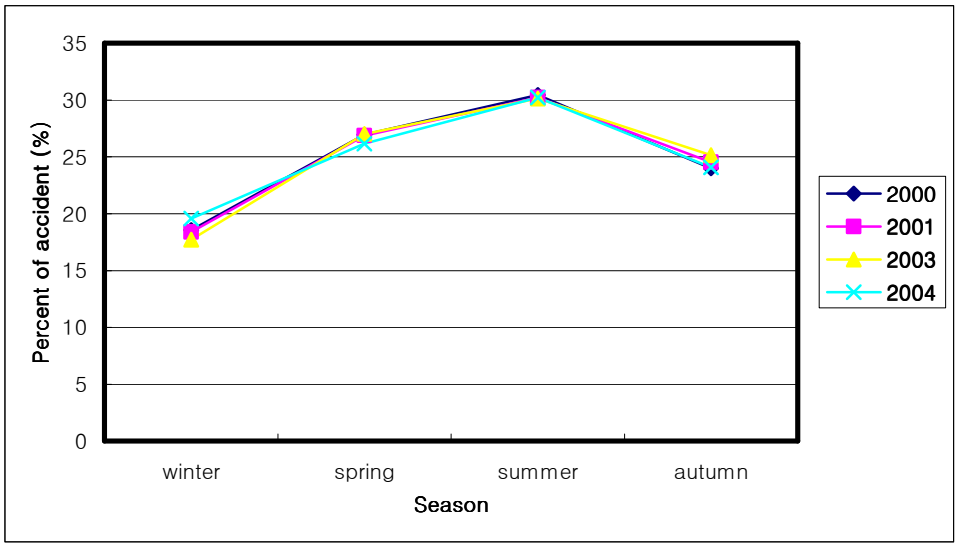

Fig. 2.27 POA patterns by season and daytime factor characteristics

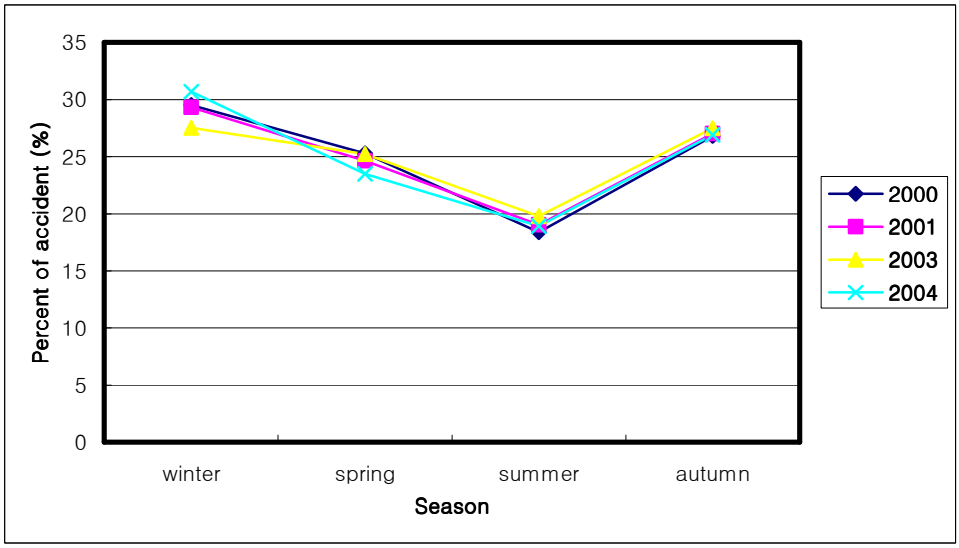

Fig. 2.28 POA patterns by season and nighttime factor characteristics

That is, the seasonal accident analysis has shown almost the similar pattern characteristics for the last 4 years regardless of the year, even though there was a considerable change in the seasonal accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the seasonal accident characteristics.

On the other hand, compared with the seasonal percent of accident (POA) between the daytime and nighttime periods for the last 5 years, the results showed that there was a considerable difference (about 11% to 12%) in the percent of accident of summer season

during the daytime period and (about 10% to 11%) in the percent of accident of winter season during nighttime period as shown in Fig. 2.25 and 2.26, and Table 2.12. That is, the POA analysis has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the number of the seasonal accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the seasonal accident characteristics.

Table 2.12 POA results by season and day-and-night factor characteristics

Season	Winter		Spring		Summer		Autumn	
Year	Day	Night	Day	Night	Day	Night	Day	Night
2000	18.6	29.5	27.0	25.3	30.5	18.4	24.0	26.8
2001	18.4	29.3	26.9	24.6	30.2	19.0	24.5	27.0
2003	17.7	27.5	27.0	25.2	30.2	19.8	25.1	27.5
2004	19.6	30.7	26.1	23.5	30.2	18.9	24.1	26.9

As a result, the day-and-night factor characteristics became an important factor for identifying the seasonal accident characteristics. Also, the accident related safety programs including the police enforcement were required for reducing the seasonal accidents.

2.3.3 Accident analysis by road type and day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between the road type accidents occurred during the daytime and nighttime periods for the last 4 years of 2000 to 2004. The number of accidents has gradually decreased since 2000. Additionally, the road type accidents were shown to be much more on the national highway than any other roads regardless of the daytime and nighttime periods as shown in Fig. 2.29 and 2.30.

On the one hand, compared with the road type accidents between the daytime and nighttime periods for the last 4 years, the results showed that there was a considerable difference (about 20,000accidents/year) on the national highway in 2000, but also a little reduction of difference (about 10,000accidents/year) in 2004. Also, they shaped the 3-dimensional polynomial shift curves with the highest explanatory power (R^2=1.0 during the daytime period and R^2=1.0 during the nighttime period). That is, the road type accident analysis has shown almost the similar pattern characteristics for the last 5 years regardless of the year, even though there was a considerable change in the road type accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the road type accident characteristics.

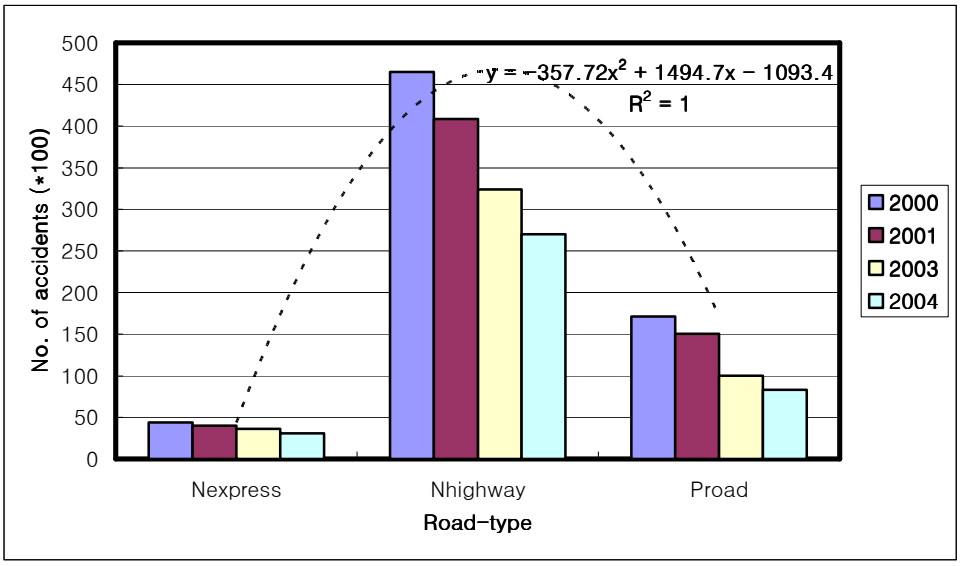

Fig. 2.29 Accident patterns by road type and daytime factor characteristics

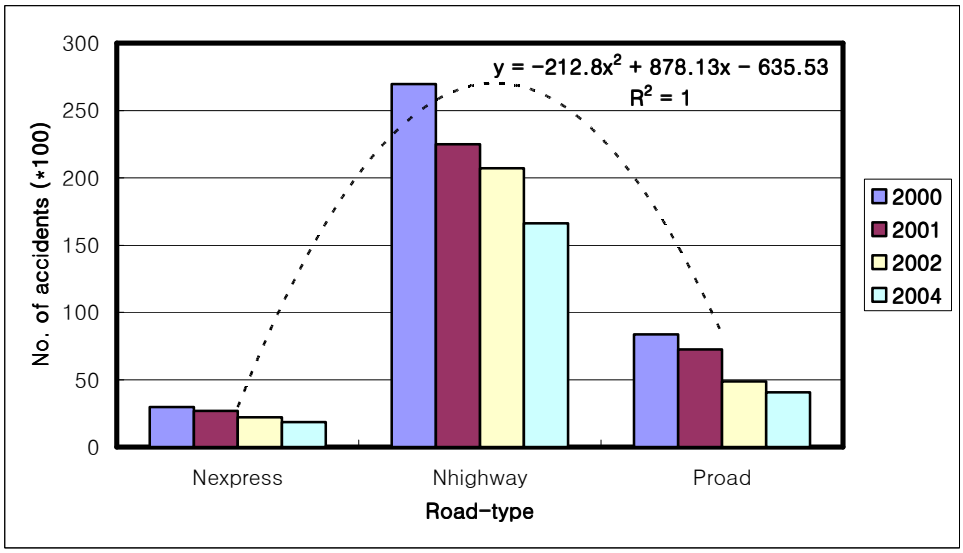

Fig. 2.30 Accident patterns by road type and nighttime factor characteristics

On the other hand, compared with the road type percent of accident (POA) between the daytime and nighttime periods for the last 4 years, the results showed that there was a little higher POA (about 1% to 4%) on the national expressway and highway during the nighttime period, and (about 3% to 4%) on the provincial roads during the daytime period as shown in Fig. 2.31 and 2.32, and Table 2.13.

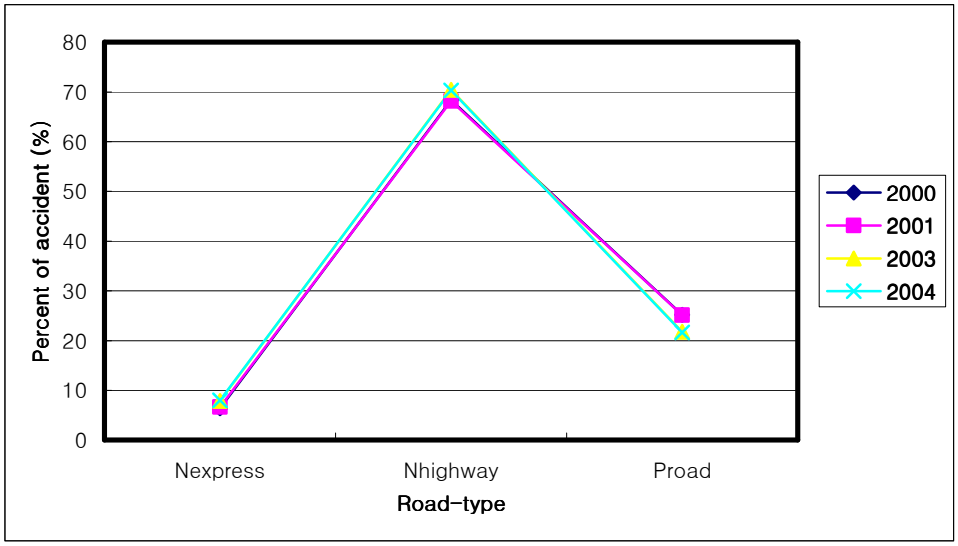

Fig. 2.31 POA patterns by road type and daytime factor characteristics

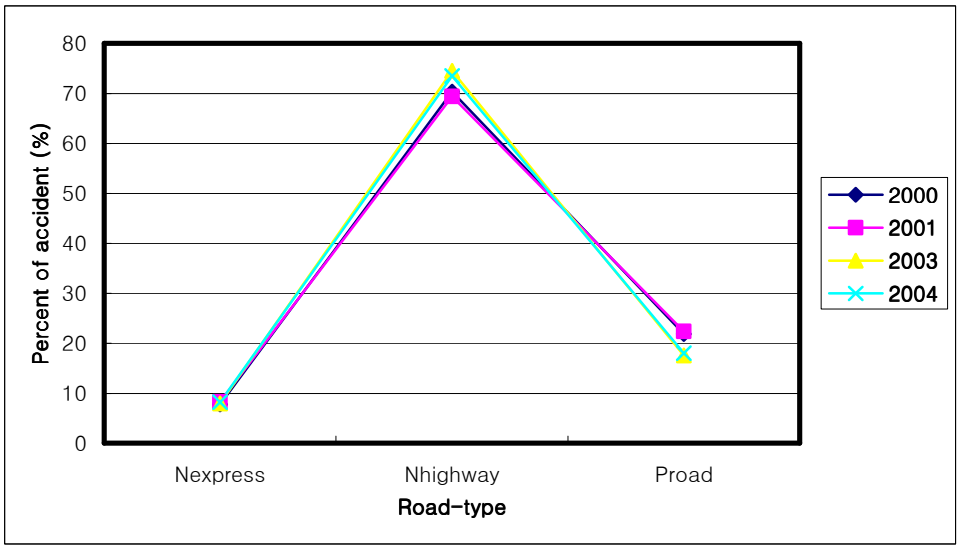

Fig. 2.32 POA patterns by road type and nighttime factor characteristics

That is, the POA analysis has shown almost the same percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the road type accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the road type accident characteristics.

Table 2.13 POA results by road type and day-and-night factor characteristics

Road type / Year	National expressway		National highway		Provincial road	
	Day	Night	Day	Night	Day	Night
2000	6.4	7.8	68.4	70.4	25.2	21.8
2001	6.7	8.3	68.2	69.4	25.1	22.4
2003	7.9	8.0	70.4	74.5	21.8	17.6

2004	8.0	8.3	70.3	73.5	21.6	18.0

As a result, the day-and-night factor characteristics became an important factor for identifying the road type accident characteristics. Also, the accident related safety programs including the police enforcement were required for reducing the road type accidents on the national highway during the daytime period, and on the provincial roads during the daytime period.

2.3.4 Accident analysis by area type and day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between the area type accidents occurred during daytime and nighttime periods for the last 4 years of 2000 to 2004. The area type accidents were shown to be much more on the suburban area than any other areas regardless of the daytime and nighttime periods as shown in Fig. 2.33 and 2.34.

On the one hand, compared with the area type accidents between the daytime and nighttime periods for the last 5 years, the results showed that there was a considerable difference (about 10,000 to 16,000accidents/year) on the urban area, (about 20,000 to 26,000accidents/year) on the suburban area and (about 8,000 to 27,000accidents/year) on the rural area. Also, they shaped the 3-dimensional polynomial shift curves with the highest explanatory power (R^2=1.0 during the daytime period and R^2=1.0 during the nighttime period). That is, the area type accident analysis has shown almost the similar pattern characteristics for the last 5 years regardless of the year, even though there was a considerable change in the area type accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the area type accident characteristics.

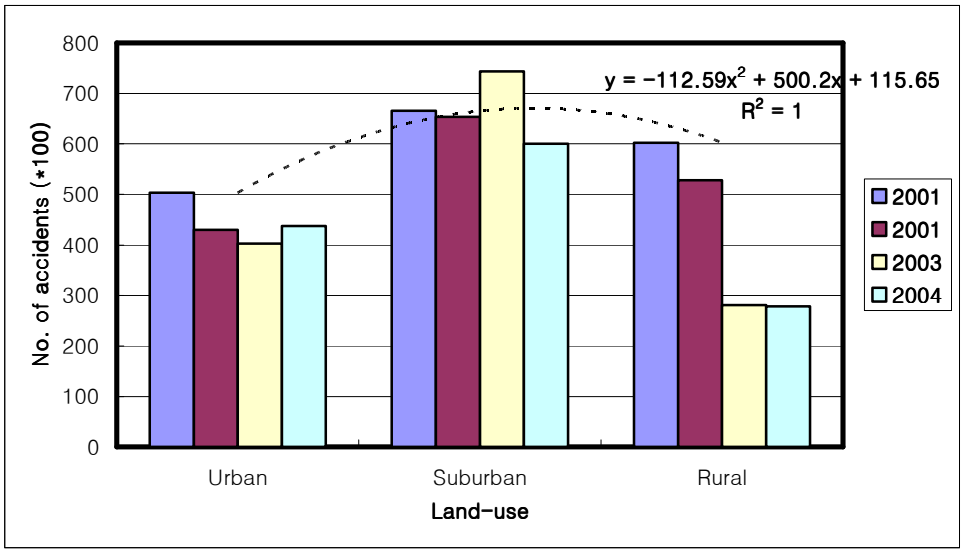

Fig. 2.33 Accident pattern by area type and daytime factor characteristics

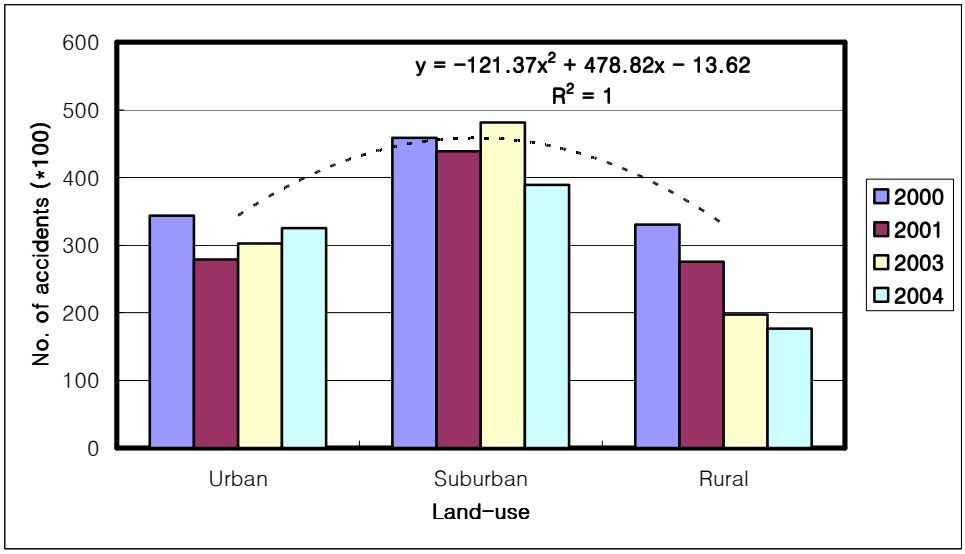

Fig. 2.34 Accident pattern by area type and nighttime factor characteristics

On the other hand, compared with the area type percent of accident (POA) between the daytime and nighttime periods for the last 4 years, the results showed that there was a little higher POA (about 1% to 3%) in the urban area during the nighttime period, and (about 0% to 5%) in the rural area during the daytime period as shown in Fig. 2.35 and 2.36. That is, the POA analysis has shown almost the similar percent of accident for the last 5 years regardless of the year, even though there was a considerable change in the area type accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the area type accident characteristics.

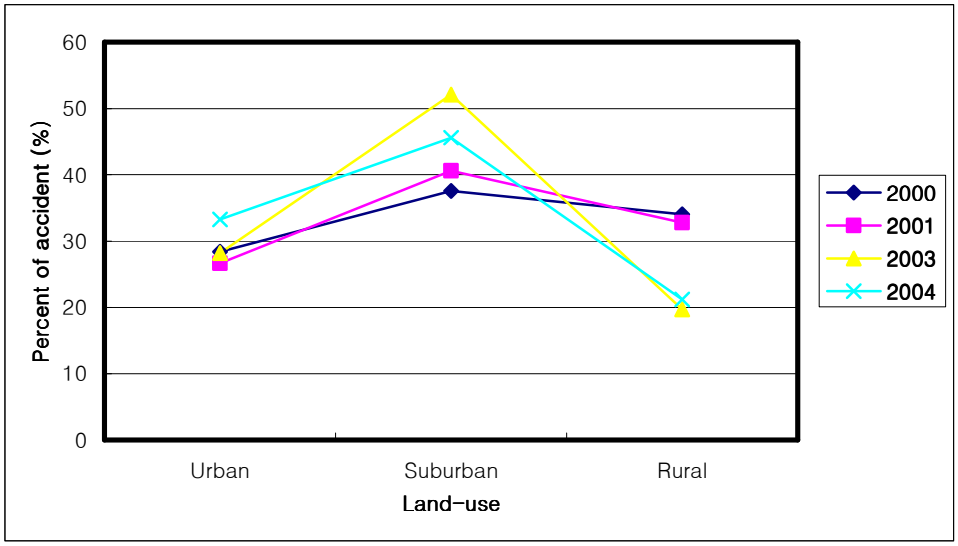

Fig. 2.35 POA pattern by area type and daytime factor characteristics

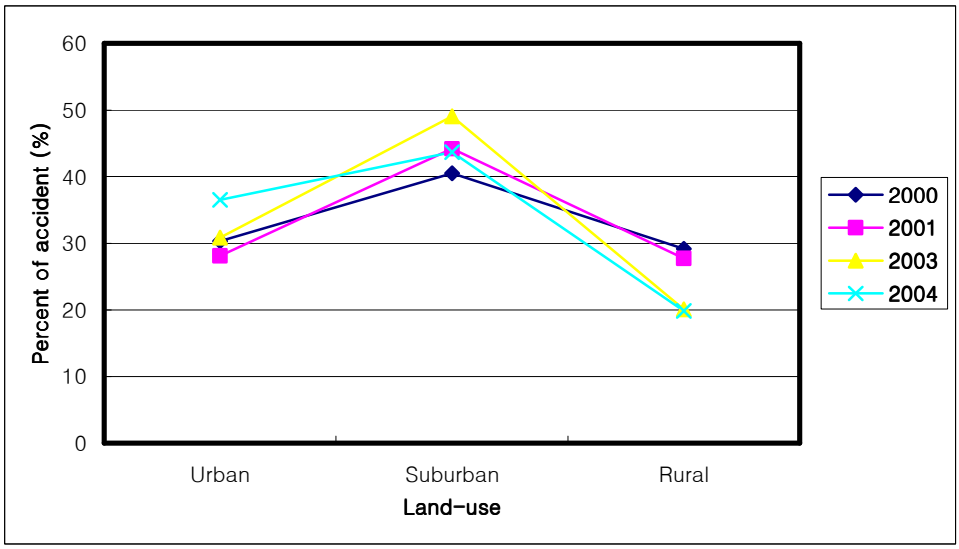

Fig. 2.36 POA pattern by area type and nighttime factor characteristics

Table 2.14 POA results by area type and day-and-night factor characteristics

Area type / Year	Urban		Suburban		Rural	
	Day	Night	Day	Night	Day	Night
2000	28.4	30.3	37.6	40.5	34.0	29.2
2001	26.6	28.0	40.6	44.2	32.8	27.8
2003	28.2	30.8	52.1	49.1	19.7	20.1
2004	33.2	36.5	45.6	43.7	21.2	19.8

As a result, the day-and-night factor characteristics became an important factor for identifying the area type accident characteristics. Also, the accident related safety programs including the police enforcement were required for reducing the area type

accidents in the urban area during the nighttime period, and those in the rural area during the daytime period.

2.3.5 Accident analysis by vehicle type and day-and-night factor characteristics

Accident analysis was conducted for making a characteristic comparison between the vehicle type accidents occurred during daytime and nighttime periods for the last 5 years of 2000 to 2004. The vehicle type accidents were shown to be much more by the passenger cars than any other types of vehicle regardless of the daytime and nighttime periods as shown in Fig. 2.37 and 2.38.

On the one hand, compared with the area type accidents between the daytime and nighttime periods for the last 5 years, the results showed that there was a considerable difference (about 13,000 to 22,000accidents/year) by the passenger car, (about 15,000 to 24,000accidents/year) by the truck, and (about 9,000 to 15,000accidents/year) by the bus during the daytime period. Also, they shaped the 3-dimensional polynomial shift curves with the highest explanatory power (R^2=0.98 during the daytime period and R^2=0.9685 during the nighttime period). That is, the vehicle type accident analysis has shown almost the similar pattern characteristics for the last 4 years regardless of the year, even though there was a considerable change in the vehicle type accidents.

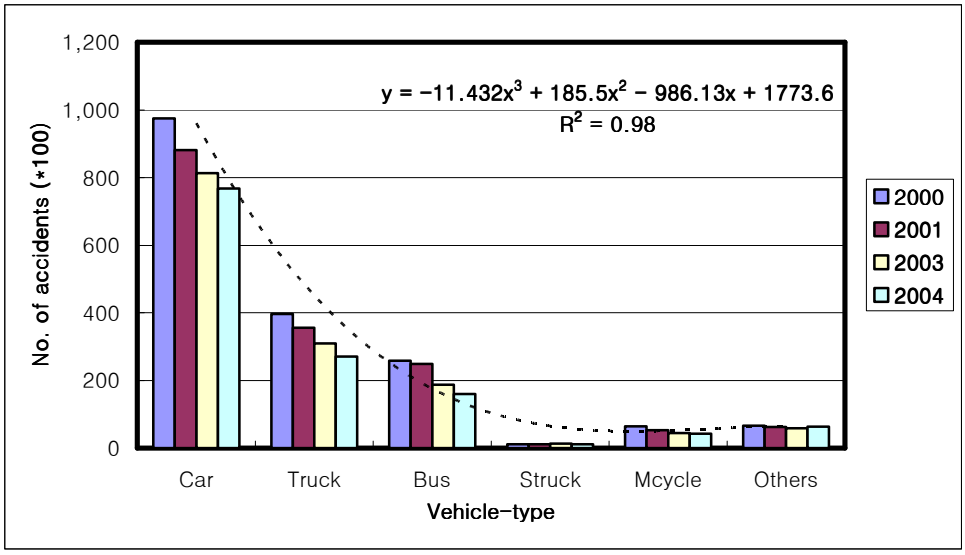

Fig. 2.37 Accident patterns by vehicle type and daytime factor characteristics

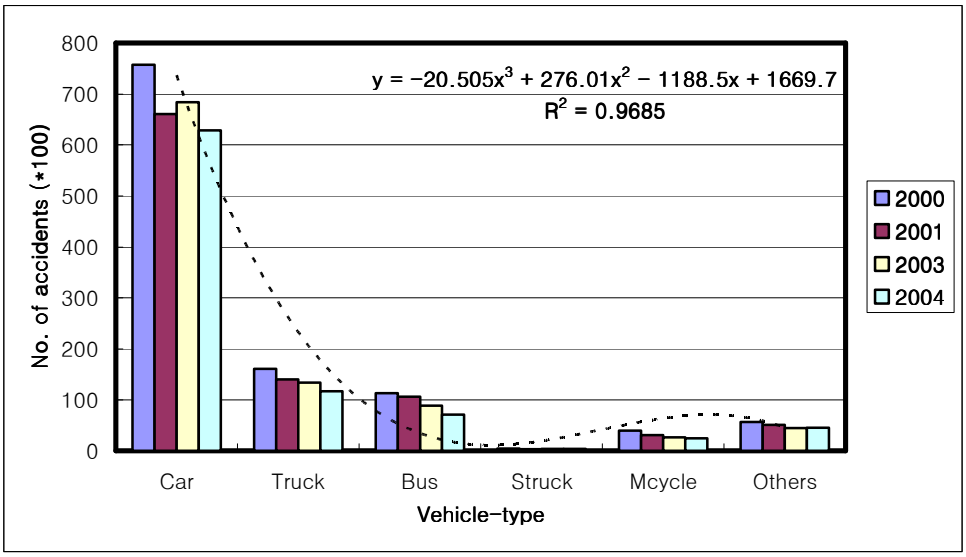

Fig. 2.38 Accident patterns by vehicle type and nighttime factor characteristics

Also, the day-and-night factor characteristics were thought to be an important factor for identifying the vehicle type accident characteristics.

On the other hand, compared with the area type percent of accident (POA) between the daytime and nighttime periods for the last 4 years, the results showed that there was a little higher POA (about 12% to 13%) by the passenger car during the nighttime period, and (about 7% to 8%) by the truck and (about 4% to 5%) by the bus during the daytime period as shown in Fig. 2.39 and 2.40, and Table 2.15.

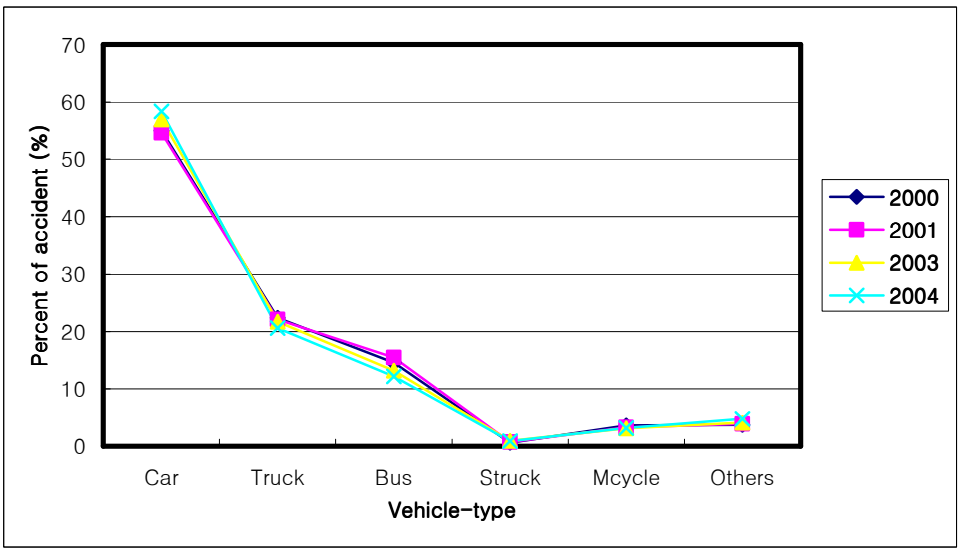

Fig. 2.39 POA patterns by vehicle type and daytime factor characteristics

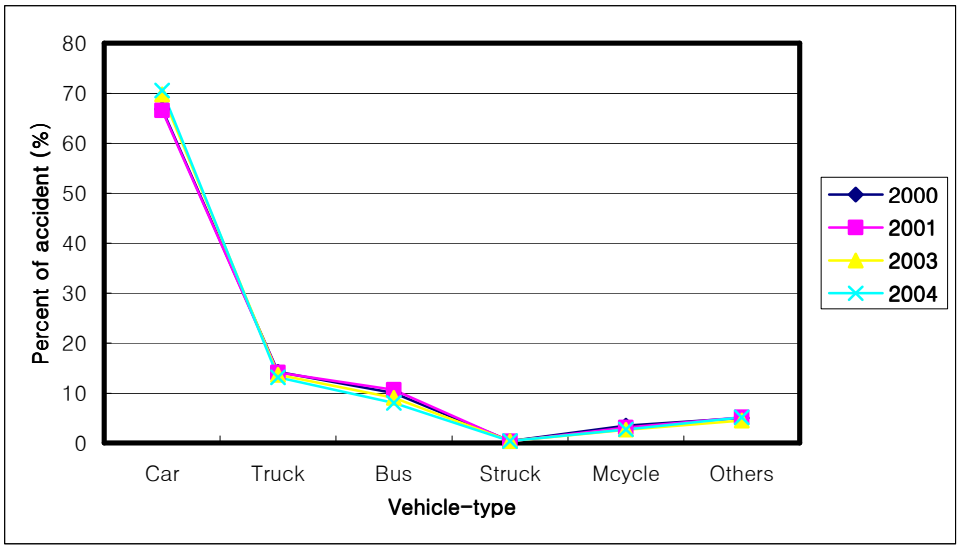

Fig. 2.40 POA patterns by vehicle type and nighttime factor characteristics

That is, the POA analysis has shown almost the same percent of accident for the last 4 years regardless of the year, even though there was a considerable change in the area type accidents. Also, the day-and-night factor characteristics were thought to be an important factor for identifying the vehicle type accident characteristics.

Table 2.15 POA results by vehicle type and day-and-night factor characteristics

Veh.	Car		Truck		Bus		Special truck		Motor cycle		Others	
Year	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
2000	55.0	66.8	22.4	14.2	14.6	10.0	0.6	0.4	3.6	3.5	3.8	5.1
2001	54.6	66.6	22.1	14.1	15.5	10.7	0.7	0.3	3.3	3.1	3.8	5.2
2003	57.0	69.7	21.7	13.7	13.2	9.0	1.0	0.4	3.1	2.7	4.0	4.5
2004	58.4	70.6	20.6	13.2	12.2	8.0	0.9	0.4	3.2	2.7	4.7	5.1

As a result, the day-and-night factor characteristics became an important factor for identifying the vehicle type accident characteristics. Also, the accident related safety

programs including the police enforcement were required for reducing traffic accidents by the passenger cars during the nighttime period, and those by the truck and bus during the daytime period.

Chapter 3 Model Development and Validation

In order to evaluate whether the accident occurrence patterns in the future could be continuously maintained or not, the accident correlation models were constructed with accident data occurred for the last 5 years (2000-2004) in Korea by using the linear regression analysis, and also validated with accident data by using the t-test analysis and correlation analysis as well.

3.1 Model Development

In the accident correlation model, accident data occurred for 2 years before, on the basis of 2002, were used as the independent variables for the accident factor characteristics, and those occurred for 2 years after on the basis of 2002 used as the dependent ones for each accident factor characteristics as follows;

Dependent variables: Houaft, Dayaft, Weeaft, Monaft, Seaaft, Regaft, Locaft, Higaft, Areaft, Vehaft, Mdyaft, Mntaft, Sdyaft, Sntaft, Hdyaft, Hntaft, Adyaft, Antaft, Vdyaft, Vntaft.

Independent variables: Houbef, Daybef, Weebef, Monbef, Seabef, Regbef, Locbef, Arebef, Vehbef, Higbef, Mdybef, Mntbef, Sdybef, Sntbef, Hdybef, Hntbef, Adybef, Antbef, Vdybef, Vntbef.

Under the assumption that the accident pattern for the 2 years before would be followed by the accident pattern for the 2 years after for each accident factor characteristics, the accident correlation model ($f(Xbef)$) was suggested as follows;

$$Xaft = \beta_0 + \beta_1 \times Xbef \qquad (1)$$

Where

β_0, β_1 : Regression coefficients

$Xaft$: The no. of accidents occurred for the last 2 years after

$Xbef$: The no. of accidents occurred for the last 2 years before, and

X : Representation of the accident factors (Hou=hour, Day=day-and-night, Wee=weekday, Mon=month, Sea=season, Loc=location, Reg=region, Are=area, Hig=road, Veh=vehicle, Mdy=month and daytime, Mnt=month and nighttime, Sdy=season and daytime, Snt=season and nighttime, Hdy=road type and daytime, Hnt=road type and nighttime, Ady=area type and daytime, Ant=area type and nighttime,

Vdy=vehicle type and daytime, and Vnt=vehicle type and nighttime)

The regression analysis was used to build the accident correlation models, which were developed by all-possible-regression selection procedures for the purpose of identifying the relationship between the dependent and independent variables with the criteria of R^2.

Table 3.1 Linear correlation models for accident factor characteristics

Accident factors	Linear correlation model	R^2	Prob.>F[1)]
Hour	Houaft=1577.04+0.7698∗Houbef	0.977	0.000
Day-and-night	Dayaft=20182.5+0.6911*Daybef	1.000	0.000
Weekday	Weeaft=5358.94+0.7015*Weebef	0.812	0.000
Month	Monaft=1812.69+0.7587*Monbef	0.775	0.000
Season	Seaaft=8880.72+0.7087*Seabef	0.800	0.003
Region	Regaft=-54.695+0.8427*Regbef	0.981	0.000
Location	Locaft=9986.72+0.6564*Locbef	0.962	0.000
Road type	Higaft=-1342.8+0.7190*Higbef	0.991	0.000
Area type	Areaft=-38426+1.2560*Arebef	0.480	0.127
Vehicle type	Vehaft=-2171.6+0.8855*Vehbef	0.996	0.000
Month and Daytime	Mdyaft=478.802+0.7766∗Mdybef	0.947	0.000
Month and Nighttime	Mntaft=979.730+0.7701*Mntbef	0.909	0.000
Season and Daytime	Sdyaft=1456.50+0.7762*Sdybef	0.973	0.000
Season and Nighttime	Sntaft=3006.07+0.7676*Sntbef	0.919	0.000
Road type and Daytime	Hdyaft=-494.13+0.6832*Hdybef	0.991	0.000
Road type and Nighttime	Hntaft=-829.54+0.7821*Hntbef	0.993	0.000
Area type and Daytime	Ldyaft=-16569+1.1043*Ldybef	0.310	0.000
Area type and Nighttime	Lntaft=-11402+1.2024*Lntbef	0.663	0.000
Vehicle type and Daytime	Vdyaft=-1021.7+0.8468*Vdybef	0.994	0.000
Vehicle type and Nighttime	Vntaft=-933.75+0.9334*Vntbef	0.998	0.000

Annotation 1)(P>｜t｜)=(p-value)

As a result of model development, the accident correlation models showed that the accident pattern for the 2 years after was linearly correlated with the accident pattern for the 2 years before as shown in Fig. 3.1～3.4. Also, the figures illustrated in the below were only one or two figures for each category. The rest of the figures developed were given in the Appendix A.

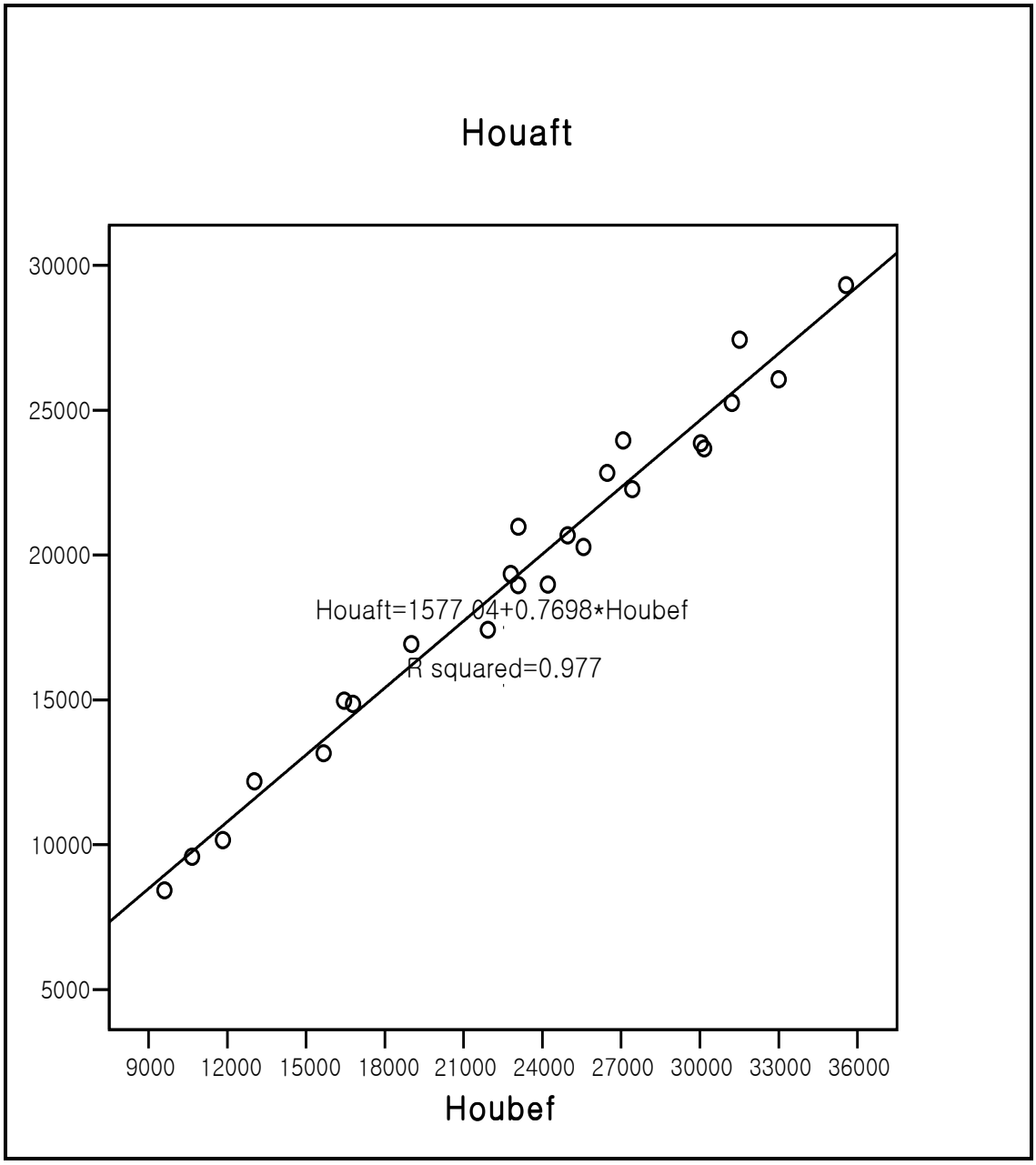

Fig. 3.1 Accident correlation model by hourly factor characteristics

First of all, the accident correlation model by the hourly factor characteristics showed a very high explanatory power between accident data before (Houbef) and after (Houaft) by showing its high coefficient of determination (R^2=0.977), as shown in Table 3.1. What was more, the accident correlation model proved to be linearly correlated between the accidents of the 2 years before and after as shown in Fig. 3.1, and very valid in the prediction of the accident pattern expected by the hourly factor characteristics in the future.

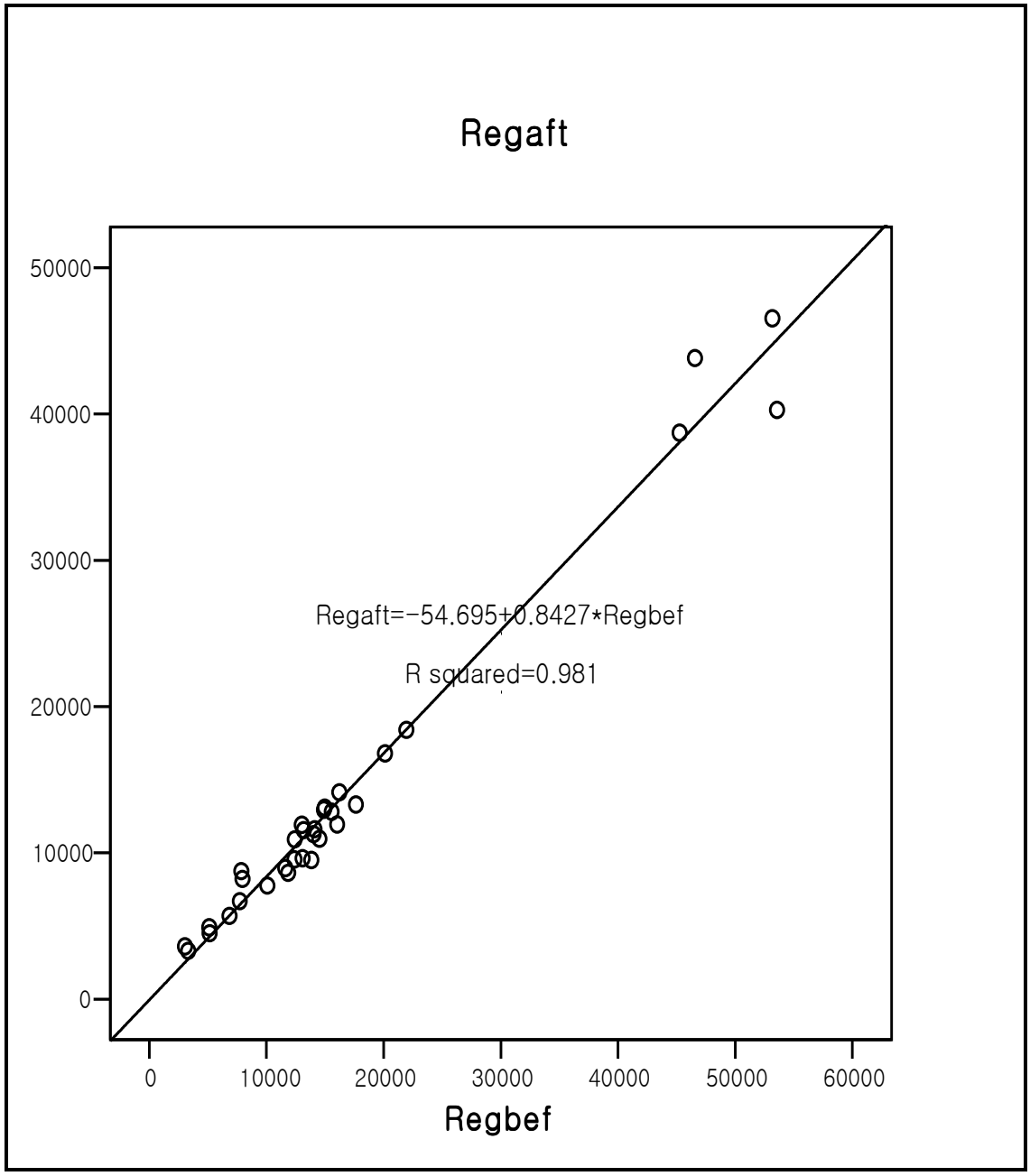

Fig. 3.2 Accident correlation model by regional factor characteristics

In addition, the accident correlation model by the regional factor characteristics showed a very high explanatory power between accident data before (Regbef) and after (Regaft) by showing its high coefficient of determination (R^2=0.981), as shown in Table 3.1. Also, the accident correlation model proved to be high linearly correlated between the accidents of the 2 years before and after as shown in Fig. 3.2, and very valid in the prediction of the accident pattern expected by the regional factor characteristics in the future.

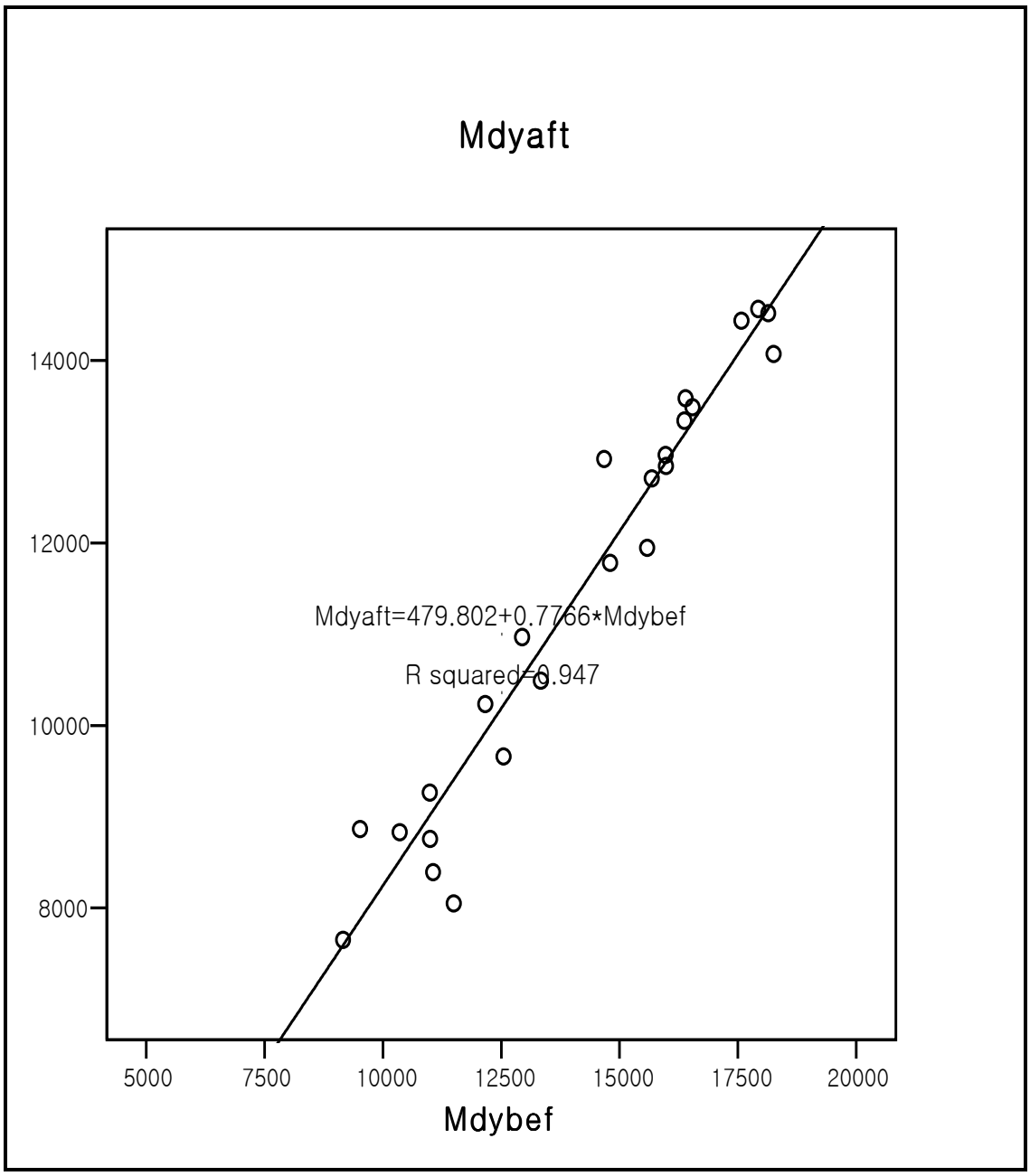

Fig. 3.3 Accident correlation model by month and daytime factor characteristics

Particularly, the accident correlation model by the month and daytime factor characteristics showed a very high explanatory power between accident data before (Mdybef) and after (Mdyaft) by showing its high coefficient of determination (R^2=0.947), as shown in Table 3.1. In addition, the accident correlation model proved to be high linearly correlated between the accidents of the 2 years before and after as shown in Fig. 3.3, and very valid in the prediction of the accident pattern expected by month-by-daytime factor characteristics in the future.

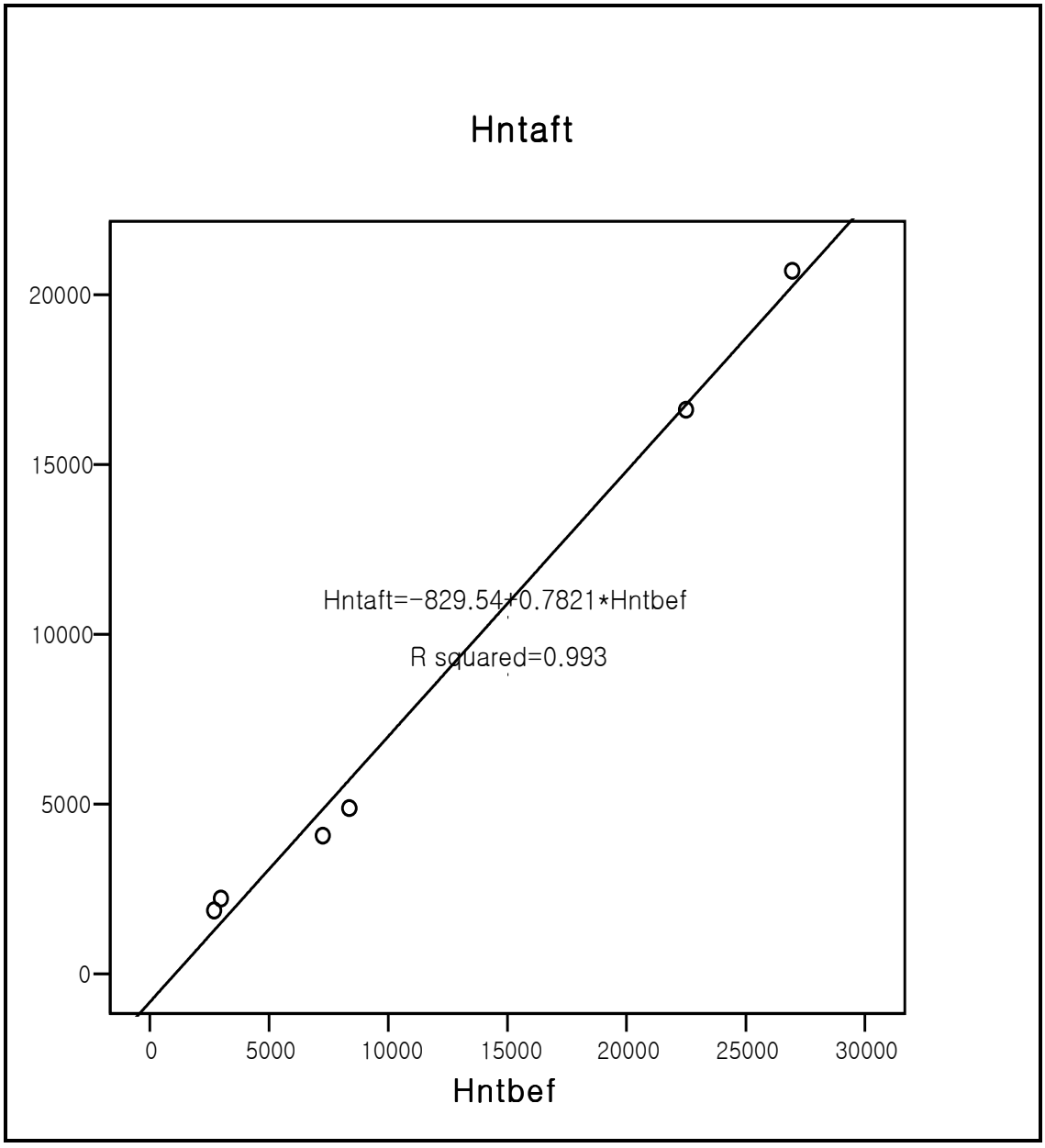

Fig. 3.4 Accident correlation model by road type and nighttime factor characteristics

Particularly, the accident correlation model by the road type and nighttime factor characteristics showed a very high explanatory power between accident data before (Hntbef) and after (Hntaft) by showing its high coefficient of determination (R^2=0.993), as shown in Table 3.1. In addition, the accident correlation model proved to be high linearly correlated between the accidents of the 2 years before and after as shown in Fig. 3.4, and very valid in the prediction of the accident pattern expected by the road type-by-nighttime factor characteristics in the future.

3.2 Model Validation

There were two approaches applied to ensure the validity of the accident correlation models developed in this study.

One approach was to conduct t-test between the observed and expected accidents, whether the two-sided p-values were greater than the significance level ($\alpha/2 = 0.025$) at the 95% confidence level or not, as shown in Table 3.2. Another approach was to test the utility of the regression models with the correlation analysis between the expected and observed accidents, as shown in Table 3.3.

As a result, the accident correlation models were shown to be valid in the prediction of the future accident pattern depending on the accident factor characteristics as follows;

Table 3.2 Results of t-test between the observed and expected accident data

Pair of factor	t-value	p-value	Result
Houexp : Houaft	0.109	0.914	T
Dayexp : Dayaft	-0.037	0.973	T
Weeexp : Weeaft	0.002	0.999	T
Monexp : Monaft	0.002	0.999	T
Seaexp : Seaaft	-0.001	0.999	T
Regexp : Regaft	0.001	0.999	T
Locexp : Locaft	0.000	1.000	T
Higexp : Higaft	-0.001	0.998	T
Areexp : Areaft	0.000	1.000	T
Vehexp : Vehaft	-0.001	0.999	T
Mdyexp : Mdyaft	0.000	1.000	T
Mntexp : Mntaft	0.001	0.999	T
Sdyexp : Sdyaft	0.000	1.000	T
Sntexp : Sntaft	0.002	0.998	T
Hdyexp : Hdyaft	-0.001	0.999	T
Hntexp : Hntaft	-0.002	0.999	T
Adyexp : Ldyaft	0.000	1.000	T
Antexp : Lntaft	0.000	1.000	T
Vdyexp : Vdyaft	-0.001	0.999	T
Vntexp : Vntaft	0.002	0.999	T

The t-test results proved to be true in all of the cases. Particularly, the probabilities were shown to be higher than 0.9 as shown in Table 3.2.

Table 3.3 Correlation analysis between the observed and expected accidents

Pair of factor	Correlation coefficient (r)	p-value
Houexp : Houaft	0.988	0.000
Dayexp : Dayaft	1.000	0.000
Weeexp : Weeaft	0.901	0.000
Monexp : Monaft	0.880	0.000
Seaexp : Seaaft	0.894	0.003
Regexp : Regaft	0.990	0.000
Locexp : Locaft	0.981	0.000
Higexp : Higaft	0.995	0.000
Areexp : Areaft	0.693	0.127
Vehexp : Vehaft	0.998	0.000
Mdyexp : Mdyaft	0.973	0.000
Mntexp : Mntaft	0.953	0.000
Sdyexp : Sdyaft	0.986	0.000
Sntexp : Sntaft	0.959	0.000
Hdyexp : Hdyaft	0.995	0.000
Hntexp : Hntaft	0.996	0.000
Adyexp : Adyaft	0.557	0.251
Antexp : Antaft	0.814	0.049
Vdyexp : Vdyaft	0.997	0.000
Vntexp : Vntaft	0.999	0.000

Based on the above results of model validation, the t-test results showed that the p-value was almost greater than 0.9 between accident data expected and observed at the 95% confidence level, except for the monthly factor, the seasonal factor, the area type factor, area type and daytime factor, and area type and nighttime factor as shown in Table 3.2. Particularly, correlation analysis proved to be very valid between accident data expected and observed by showing a very high correlation coefficient (r) greater than 0.9, except for area type factor, area type and daytime, area type and nighttime cases as shown in Table 3.3. Additionally, the accident correlation models proved to be very valid in most of the accident factor characteristics, except for area type factor characteristics, as shown in Fig. 3.5 ~ 3.8. Also, the figures illustrated in the below were only one or two figures for each category. The rest of the figures validated were given in the Appendix B.

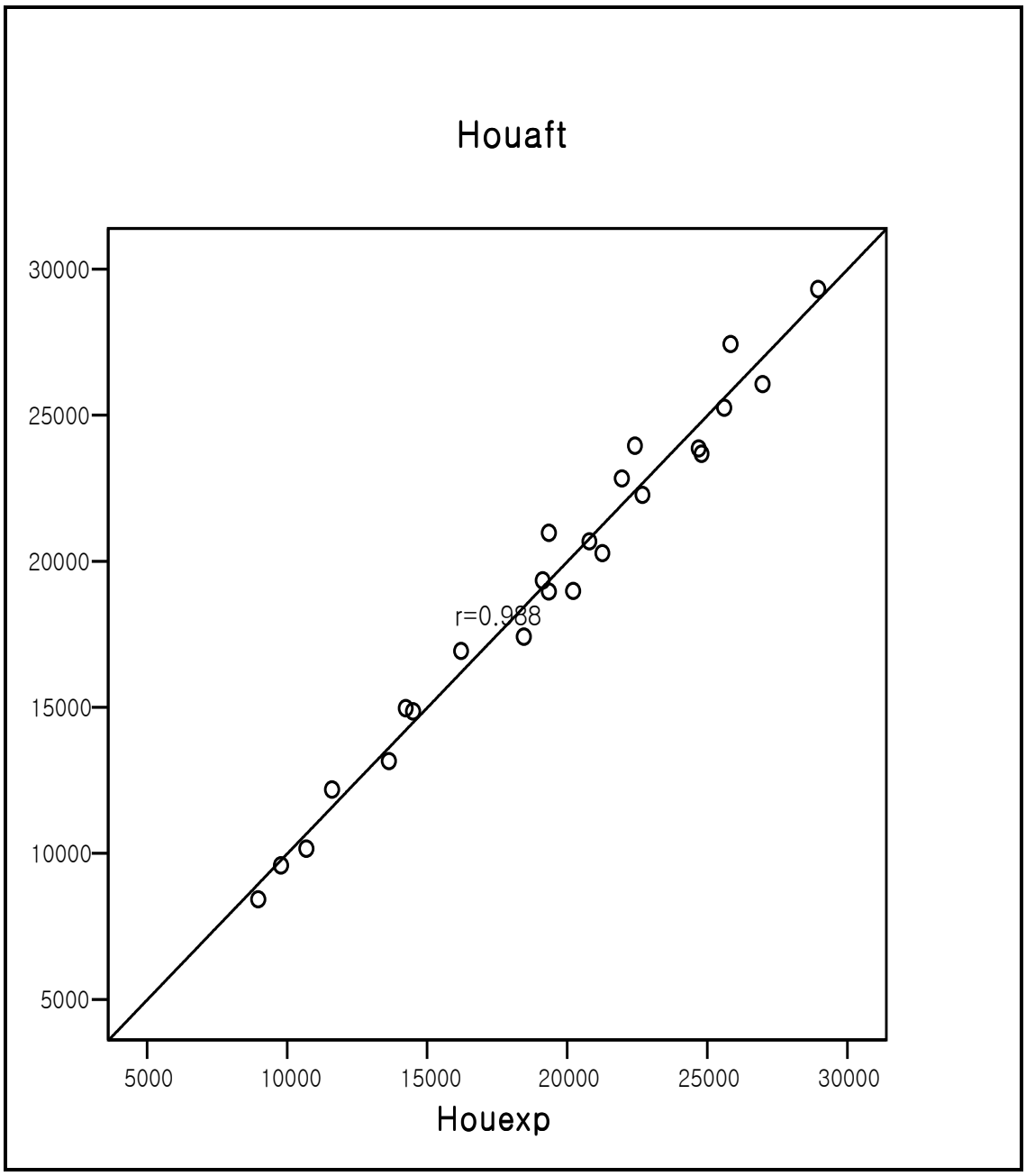

Fig. 3.5 Correlation between the observed and expected accidents by hourly factor characteristics

As a result of model validation in the accident correlation model developed by the hourly factor characteristics, the t-test result showed that the p-value was almost 1.000 between accident data expected (Houexp) and observed (Houaft) at the 95% confidence level as shown in Table 3.2. Also, correlation analysis proved to be very valid between accident data expected (Houexp) and observed (Houaft) by showing a very high correlation coefficient (r) of 0.988, as shown in Fig. 3.5 and Table 3.3.

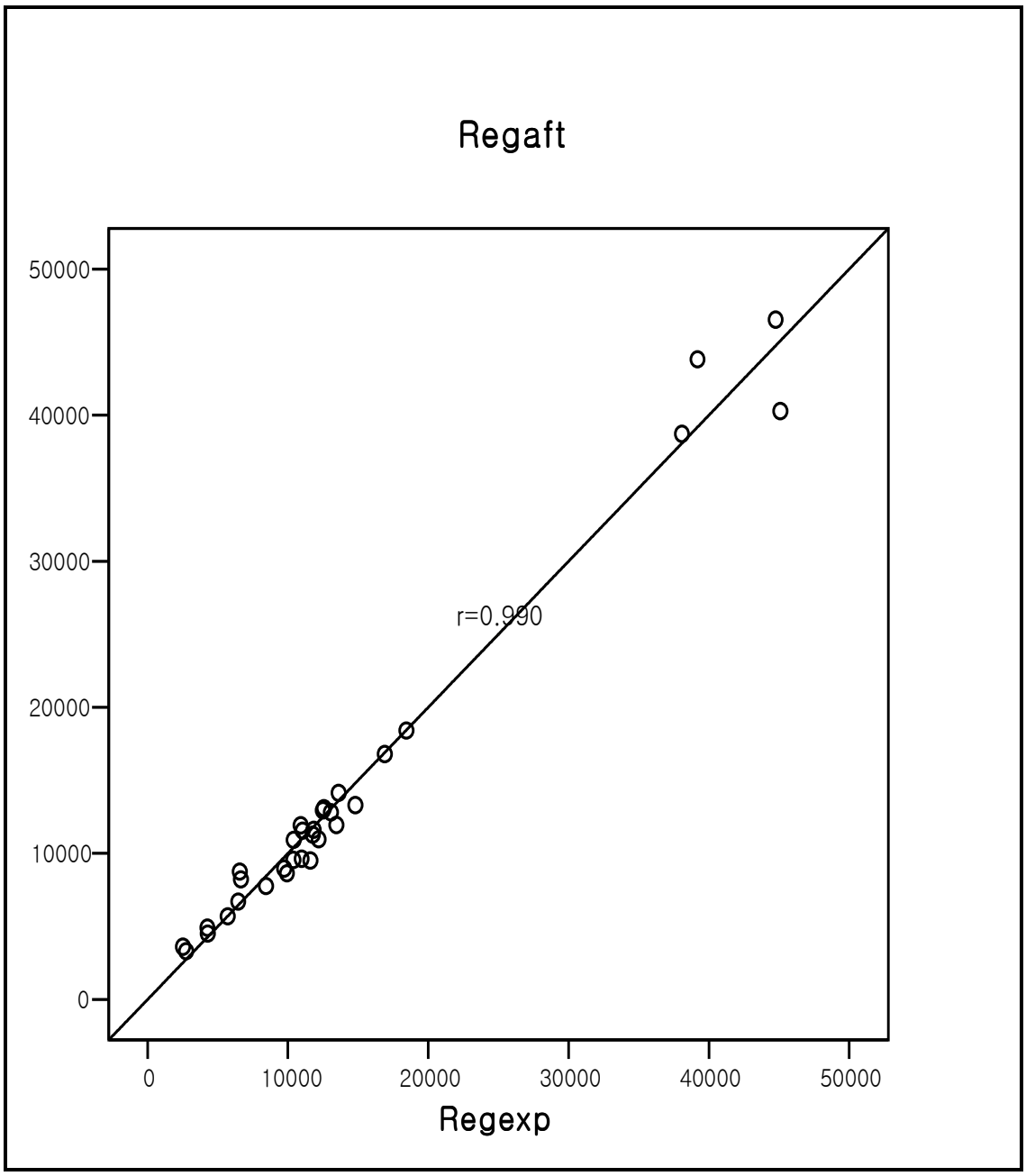

Fig. 3.6 Correlation between the observed and expected accidents by regional factor characteristics

As a result of model validation in the accident correlation model developed by the regional factor characteristics, the t-test result showed that the p-value was almost 0.000 between accident data expected (Regexp) and observed (Regaft) at the 95% confidence level as shown in Table 3.2. Also, correlation analysis proved to be very valid between accident data expected (Regexp) and observed (Regaft) by showing a very high correlation coefficient (r) of 0.990, as shown in Fig. 3.6 and Table 3.3.

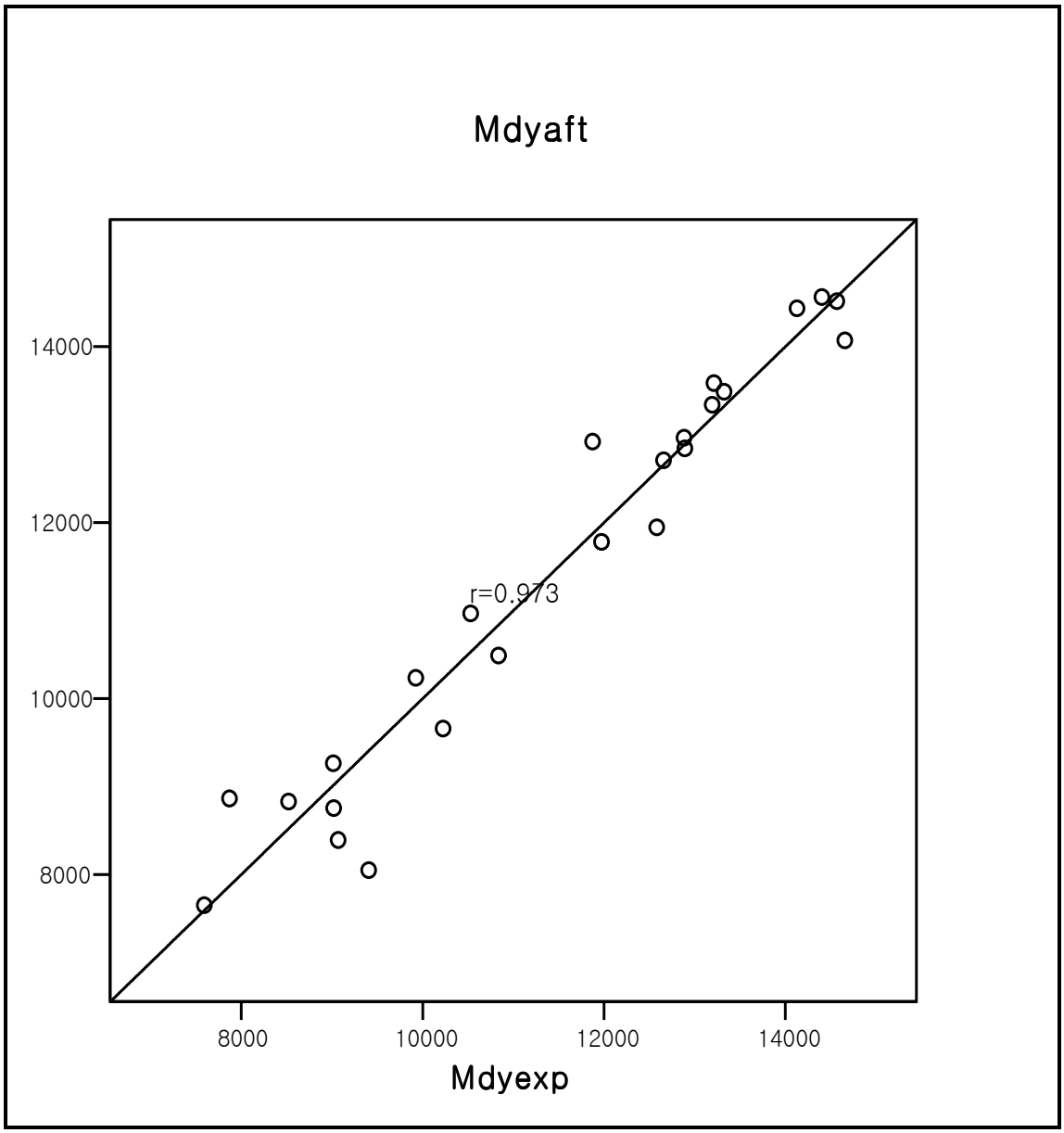

Fig. 3.7 Correlation between the observed and expected accidents by month and daytime factor characteristics

As a result of model validation in the accident correlation model developed by the month and daytime factor characteristics, the t-test result showed that the p-value was almost 0.000 between accident data expected (Mdyexp) and observed (Mdyaft) at the 95% confidence level as shown in Table 3.2. Also, correlation analysis proved to be very valid between accident data expected (Mdyexp) and observed (Mdyaft) by showing a very high correlation coefficient (r) of 0.973, as shown in Fig. 3.7 and Table 3.3.

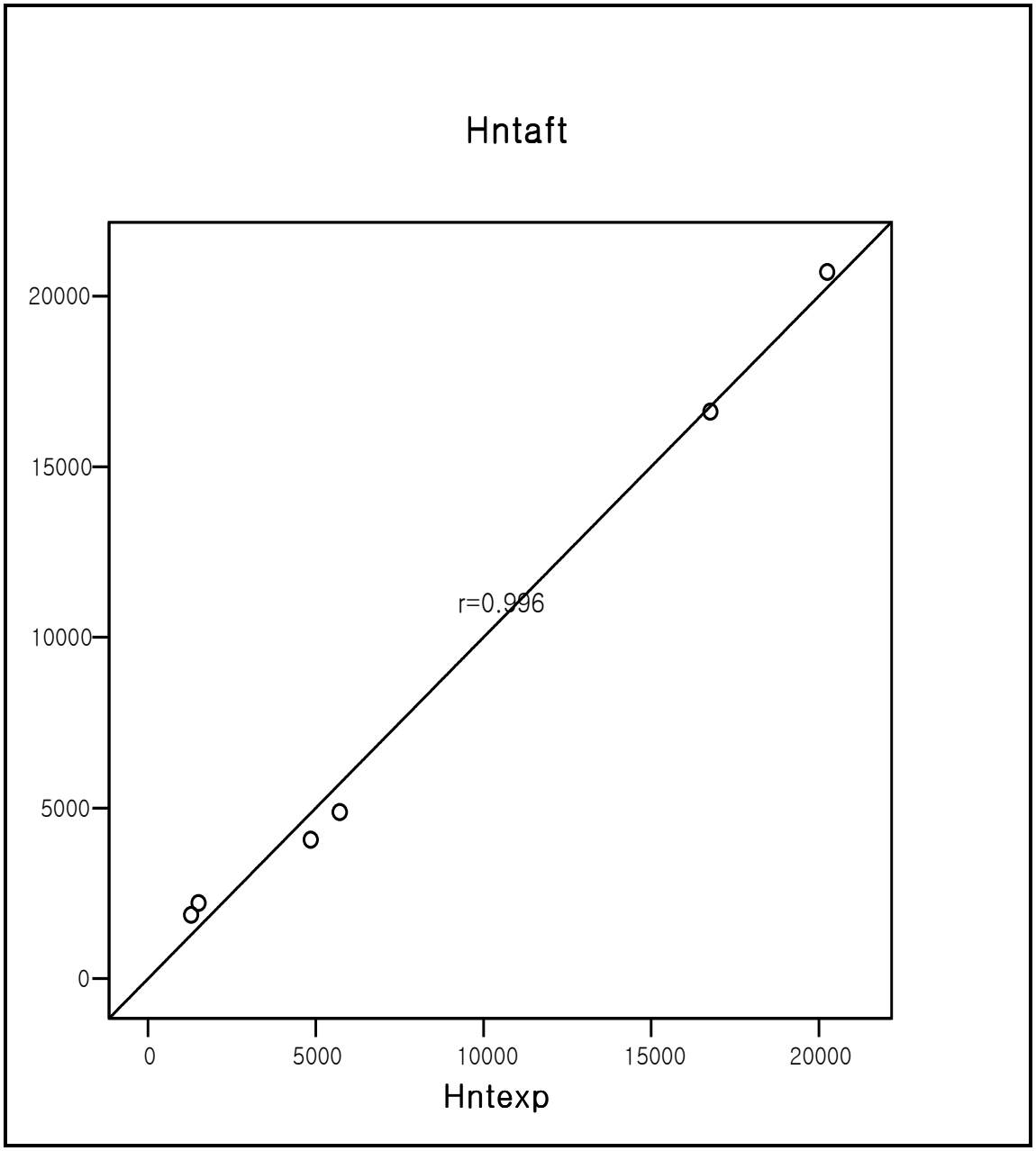

Fig. 3.8 Correlation between the observed and expected accidents by road type and nighttime factor characteristics

As a result of model validation in the accident correlation model developed by the road type and nighttime factor characteristics, the t-test result showed that the p-value was almost 0.000 between accident data expected (Hntexp) and observed (Hntaft) at the 95% confidence level as shown in Table 3.2. Also, correlation analysis proved to be very valid between accident data expected (Hntexp) and observed (Hntaft) by showing a very high correlation coefficient (r) of 0.996, as shown in Fig. 3.8 and Table 3.3.

From the above results, model development showed that the accident factor

characteristics had a high correlation with the accident pattern except for weekday, month, season and area type factors. However, when accident data were classified into the daytime and nighttime periods, accident correlation models showed that the accident factor characteristics had a higher correlation with the accident pattern except for area type factor. Additionally, model validation showed that the expected and observed data were almost same by the t-test results at the 95% confidence level, and also linearly correlated with each other, except for the area type factor with a higher validity. Thus, the accident factor characteristics proved to be very important for identifying the accident pattern, and also the 3-dimensional polynomial shift curves to be very valid in the accident characteristic analyses.

Chapter 4 Conclusions and Suggestions

4.1 Conclusions

Motor vehicles in Korea have constantly increased with a rapid growth of economy and industry since 1980's, especially 1988 Seoul Olympic Game. Also, the number of traffic accidents has continuously increased with the increase of motor vehicles by 2000, and gradually decreased by 2004 since then. Thus, the accident correlation analyses were conducted based on a master dataset of 2000 to 2004, in order to investigate the characteristics of traffic accidents which have decreased since 2000 and predict the accident occurrence patterns whether the accident characteristics would be continued after 2004 or not. From the accident analysis, and the development and verification of accident correlation models, the following conclusions were drawn:

ⅰ) Traffic accident patterns showed a uniform pattern with the 3-dimensional polynomial shift curve and a high determination coefficient (R^2) for each accident factor characteristics. However, the percent of traffic accidents showed almost an equal percent for each year, even if traffic accidents have continuously reduced since 2000.

ⅱ) More traffic accidents occurred during the 2-hour period right after the rush hour in the afternoon than any other time periods, the daytime period than the nighttime period, the day before weekend than any other weekdays, and from March to October than any months, according to the periodic factor characteristics.

ⅲ) More traffic accidents occurred in the Capital Region than any other regions, in the intersection than any other locations, on the national highway than any other road types, in the suburban area than any other area types, and by passenger cars than any other vehicle types, according to the non-periodic factor characteristics.

ⅳ) Accident correlation models showed a very high explanatory power between the last 2 years before and after, and also a very high correlation between the expected and observed data, except for weekday, monthly, seasonal, area type factor characteristics based on the development and verification of the accident correlation models.

ⅴ) Traffic accident patterns showed a very high correlation with the 3-dimensional polynomial shift curves except for the monthly factor (R^2=0.5231) in the periodic factor characteristics and the regional factor (R^2=0.8542) in the non-periodic factor characteristics.

ⅵ) Traffic accident patterns particularly showed a much higher correlation with the 3-dimensional polynomial shift curves, when compared with the traffic accident patterns of the accident factor characteristics classified into the daytime and nighttime periods than those characteristics not classified into the daytime and nighttime periods.

4.2 Suggestions

Traffic accidents have gradually decreased by 2004 despite the continuous increase of motor vehicles registered since 2000. Thus, based on the accident analysis, and the development and verification of accident correlation models, the following suggestions were drawn:

ⅰ) The transportation policies such as the staggered work hour, reversible lane, reduced business travel, the five day work week or communication substitutes programs were suggested for the reduction of the need to travel and the improvement of the safety to travel by the periodic factor characteristics.

ⅱ) The transportation policies such as the zoning/area type control, the communication substitute, the improved signal systems, redesigning intersection, the ramp metering of freeway, the land use control, the limit hours and location of travel, or the reduced business travel programs were also suggested for the reduction of the need to travel and the improvement of the safety to travel by the non-periodic factor characteristics.

ⅲ) The transportation measures should be established for the reduction of traffic accidents during 2-hour right after the afternoon rush hour, the daytime period, the day before weekend, the months from March to October, and the seasons from spring to autumn by the periodic factor characteristics.

ⅳ) The transportation measures should be particularly established for the reduction of traffic accidents in the Capital Region, at the intersection and other locations, on the national highway, in the suburban areas, or by the passenger cars by the non-periodic factor characteristics.

Therefore, since the accident occurrence patterns in Korea were thought to show the equal patterns after 2004, especially except for the area type factor characteristics, the appropriate counter-measures to be established for the reduction of traffic accidents. Also, more accident occurrence patterns in the future were needed to be studied for the accident factor characteristics such as age, sex, or drinking of driver, if possible.

References

[1] American Association of State Highway and Transportation Officials, *Transportation Glossary*, AASHTO, Washington, 1983.

[2] Choi, K. T., "A Study on the Development of Forecasting Model for Traffic Accident using Regression Analysis", Master Thesis, Graduate School of Industry at Chosun University, Feb., 2003.

[3] Choueiri, E. M., Choueiri, G. M., and Choueiri, B. M., "An Overview of Road Safety in Lebanon," *Institute of Transportation Engineers*, Jan., 32-37, 1997.

[4] Federal Highway Administration, *Highway Statistics Publications – Office of Policy Information*, www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.htm, 2007.

[5] Jadaan, K. S., "An Overview of Road Safety in New Zealand," *Institute of Transportation Engineers*, Apr., 41-45, 1993.

[6] Kim, J. S., "A Study on the Analysis of Traffic Accident Related Factors of At-Grade Intersection in Metropolitan Urban Area," Ph. D. Dissertation, Graduate School at Yeungnam University, Dec., 2001.

[7] Lee, I. S., "Application of ZIP regression to traffic accident data," Master Thesis, Graduate School at Yonsei University, Dec., 2004.

[8] Ministry of Construction and Transportation, *National Transportation Database Center*, www.ktdb.go.kr., 2007.

[9] Orne, D. E. and Yang, A. H., "An investigation of weather factor effects on traffic accidents", Traffic Engineering, Oct., 14-20, 1972.

[10] Park, J. S., "Factors and Characteristics Analysis of Intersection Traffic Accidents," Master Thesis, Graduate School at Chonnam National University, Aug., 1998.

[11] Road Traffic Safety Authority, *Trend of Traffic Accidents*, www.rtsa.or.kr., 2007

[12] Taylor, M. A.P., "A PC-Based Method for Traffic Impact Analysis," *Institute of Transportation Engineers*, Jun., 27-32, 1987.

[13] USA Statistics in Brief, *US Census Bureau*, www.census.gov/compendia/statab/brief.html, 2007.

Appendices

The rest of the figures developed by the accident correlation models in Chapter 3 are in Appendix A, and the rest of the figures validated by the t-test and correlation analysis are in Appendix B:

- Appendix A: Accident correlation models.
- Appendix B: T-test and correlation analysis.

Appendix A

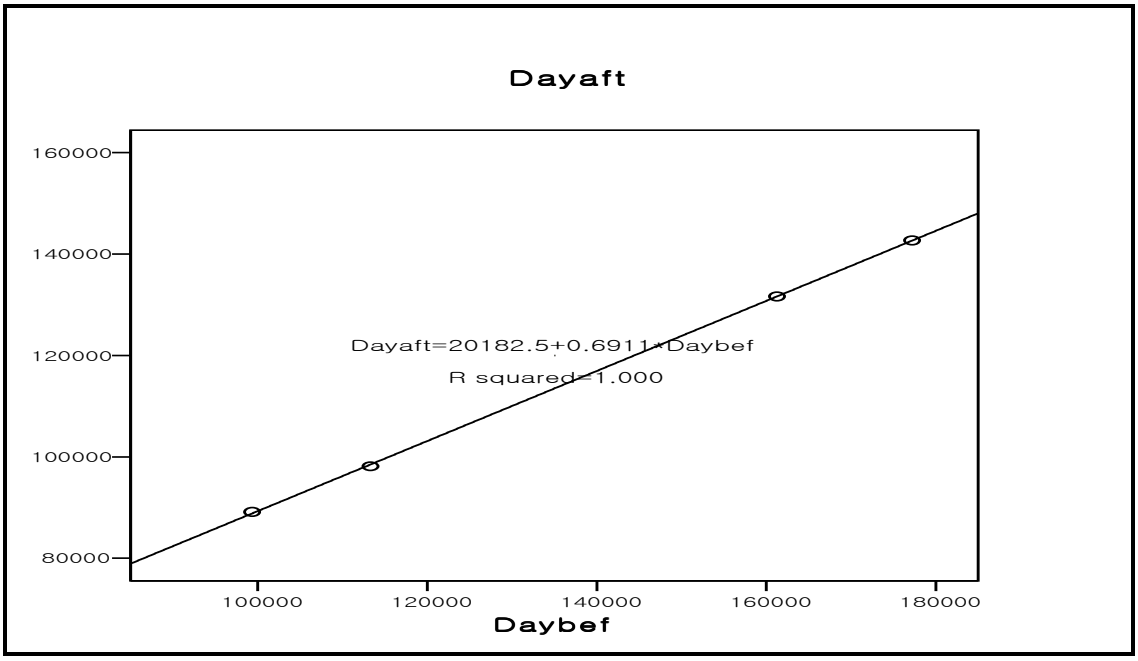

Fig. A.1 Accident correlation model by day-and-night factor characteristics

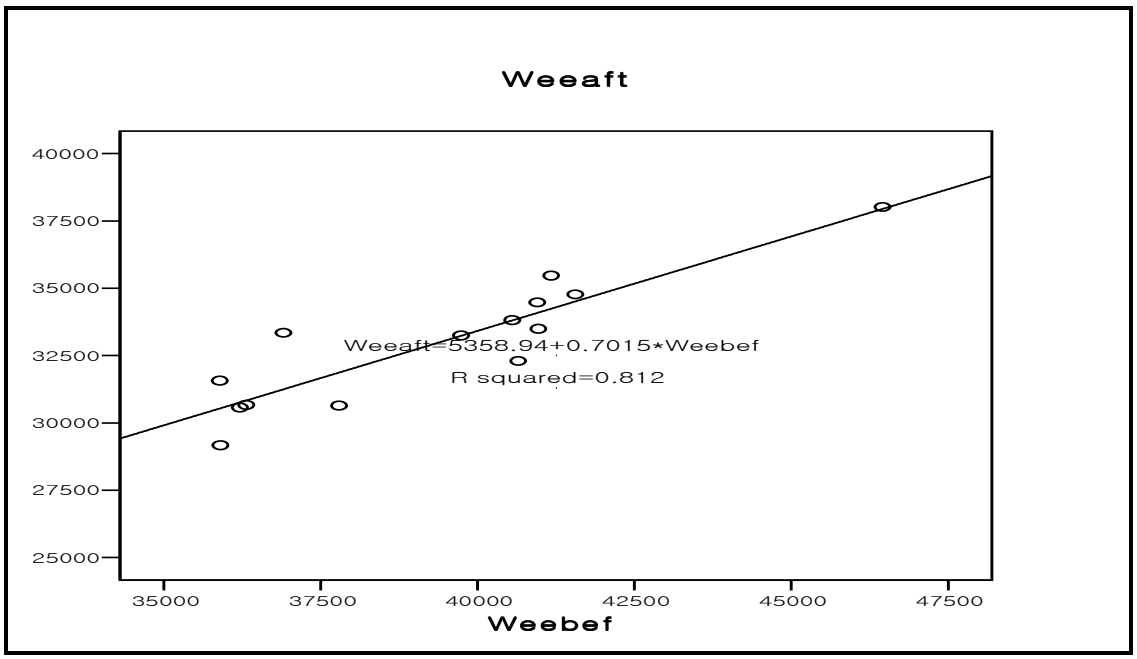

Fig. A.2 Accident correlation model by weekday factor characteristics

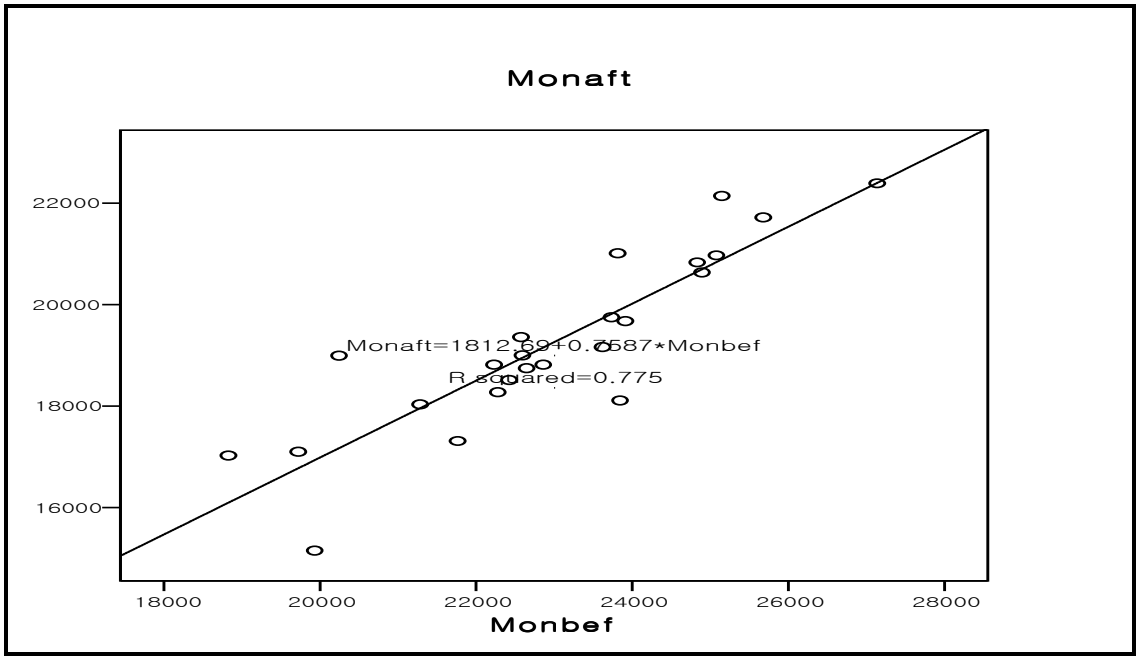

Fig. A.3 Accident correlation model by monthly factor characteristics

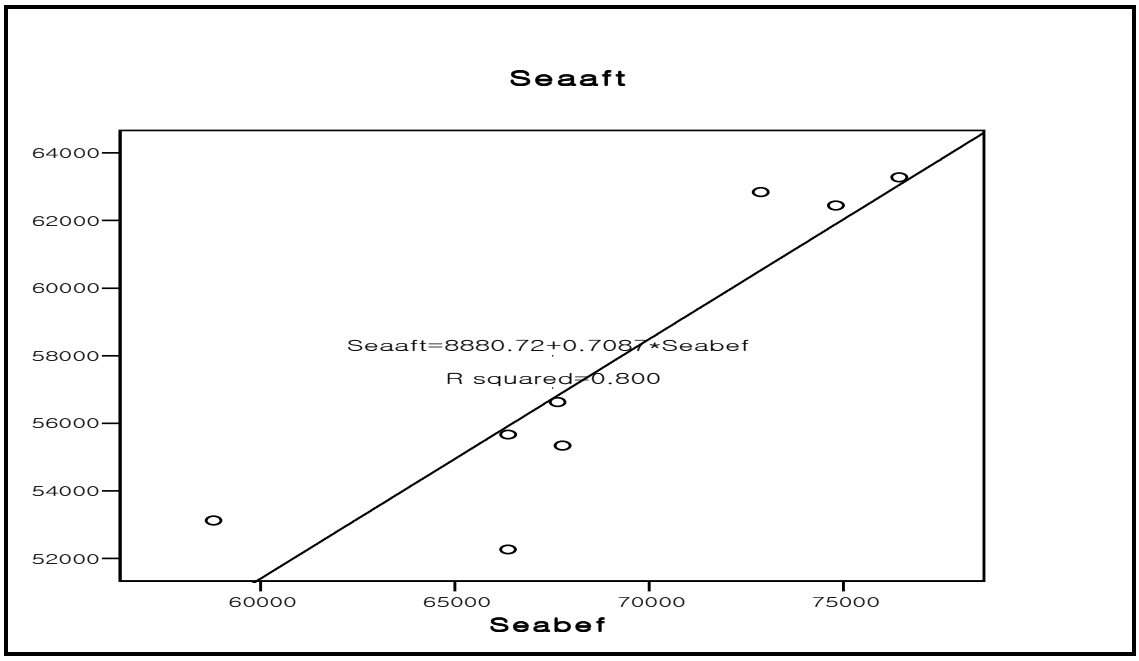

Fig. A.4 Accident correlation model by seasonal factor characteristics

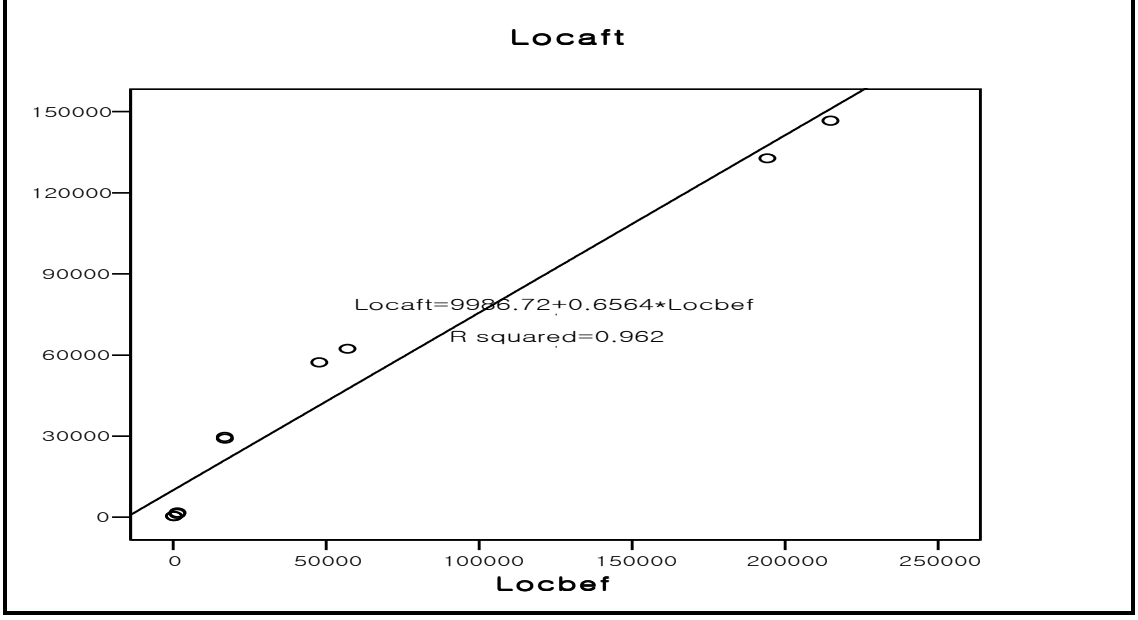

Fig. A.5 Accident correlation model by location factor characteristics

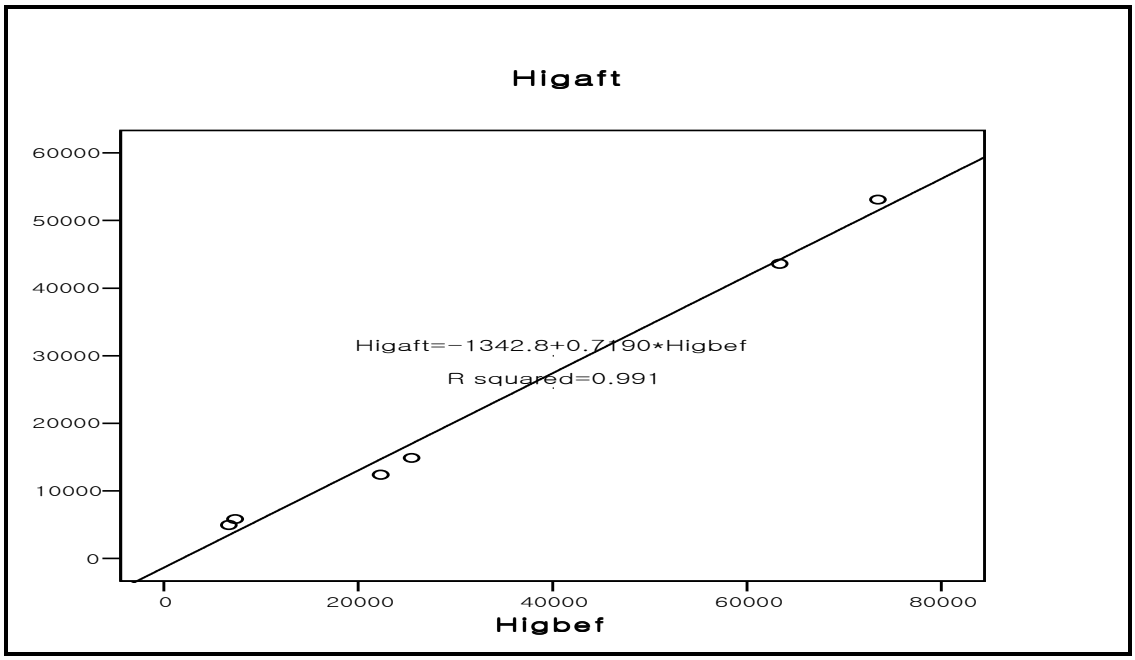

Fig. A.6 Accident correlation model by road type factor characteristics

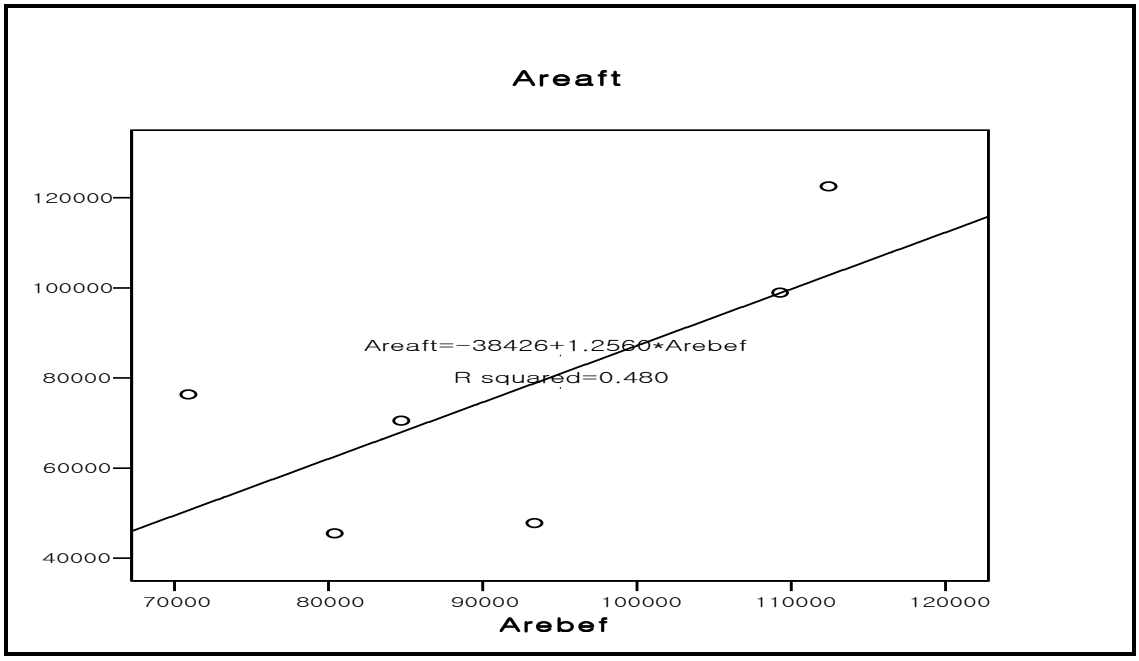

Fig. A.7 Accident correlation model by area type factor characteristics

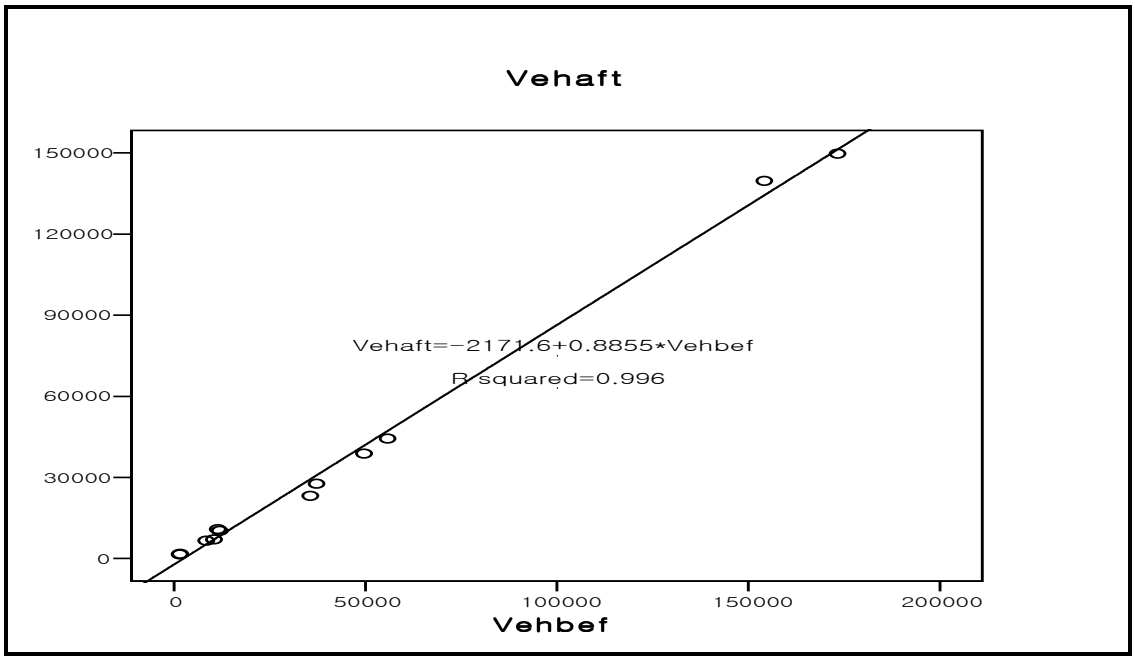

Fig. A.8 Accident correlation model by vehicle type factor characteristics

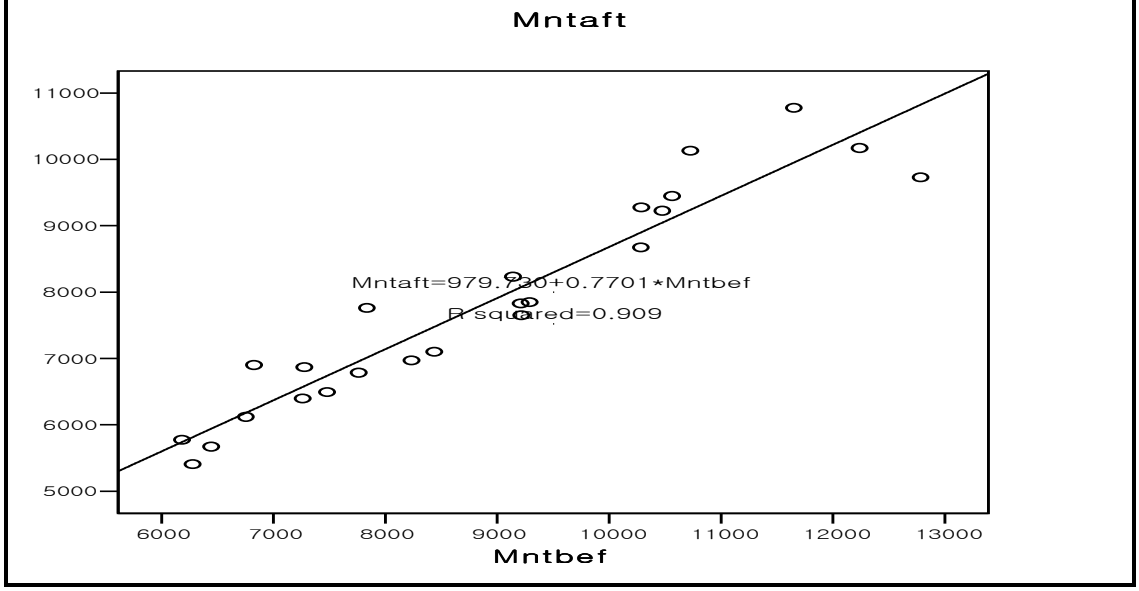

Fig. A.9 Accident correlation model by month and nighttime factor characteristics

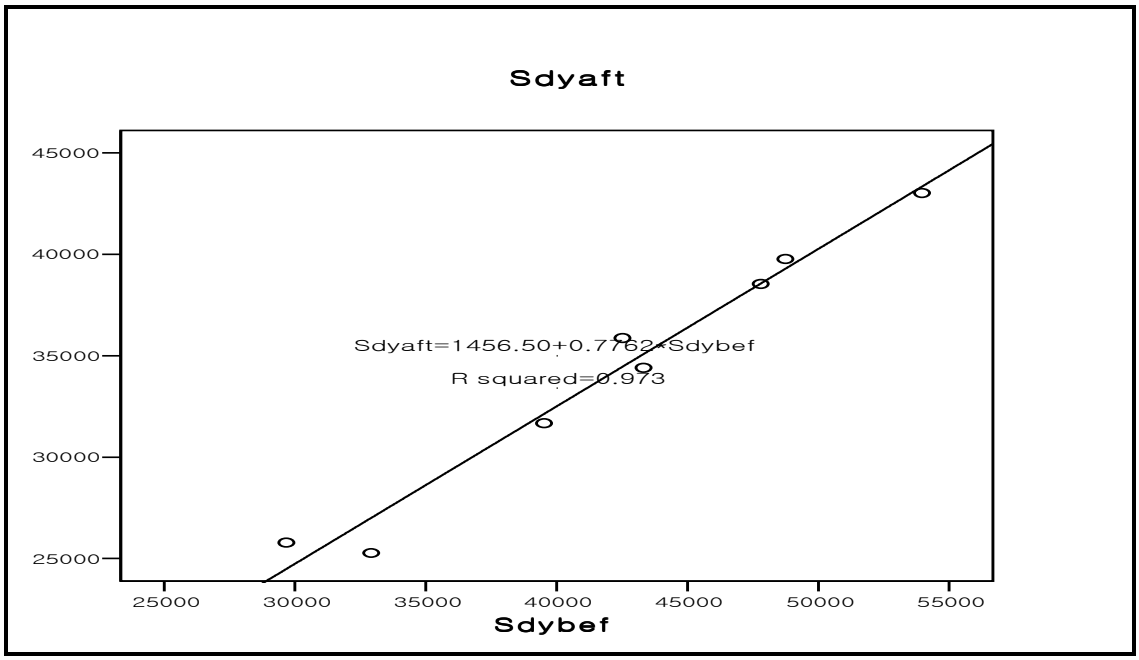

Fig. A.10Accident correlation model by season and daytime factor characteristics

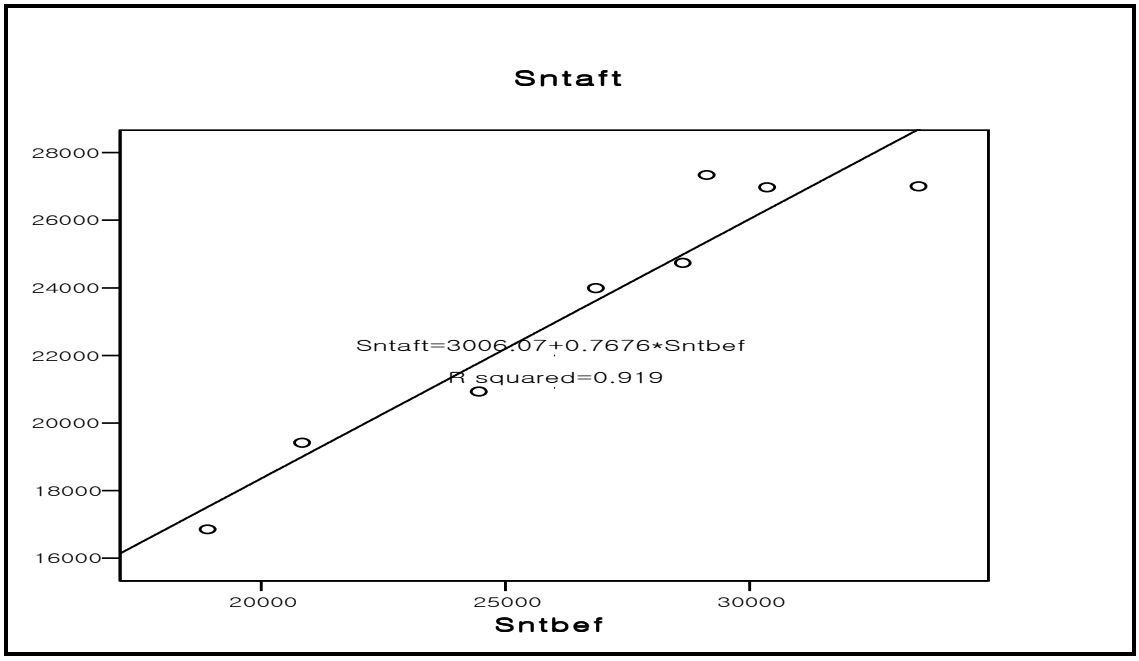

Fig. A.11Accident correlation model by season and nighttime factor characteristics

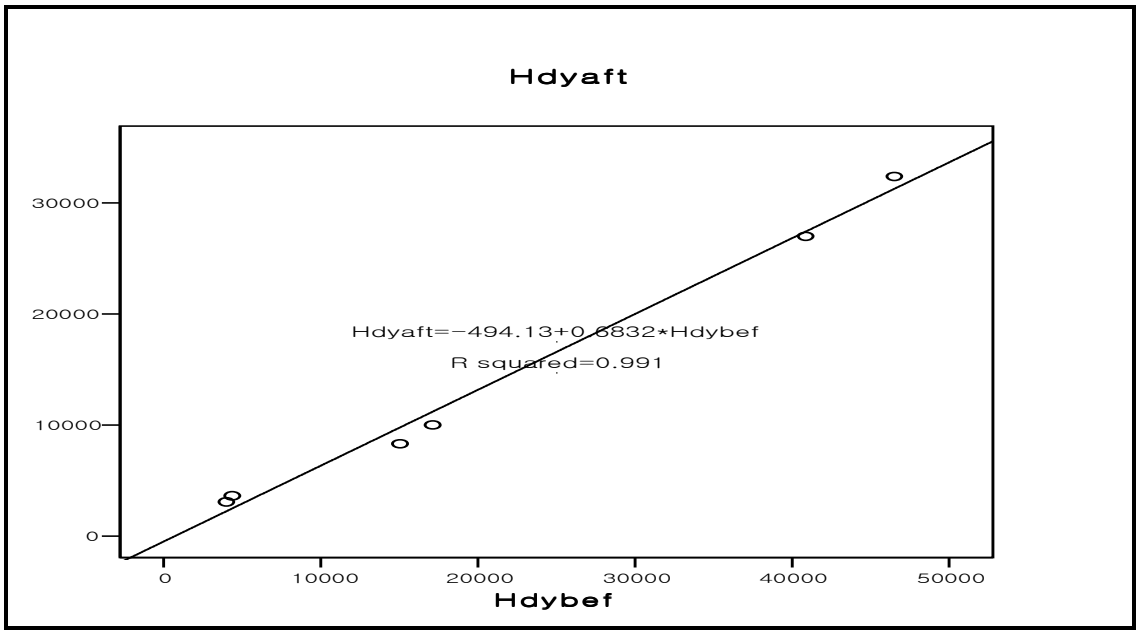

Fig. A.12 Accident correlation model by road type and daytime factor characteristics

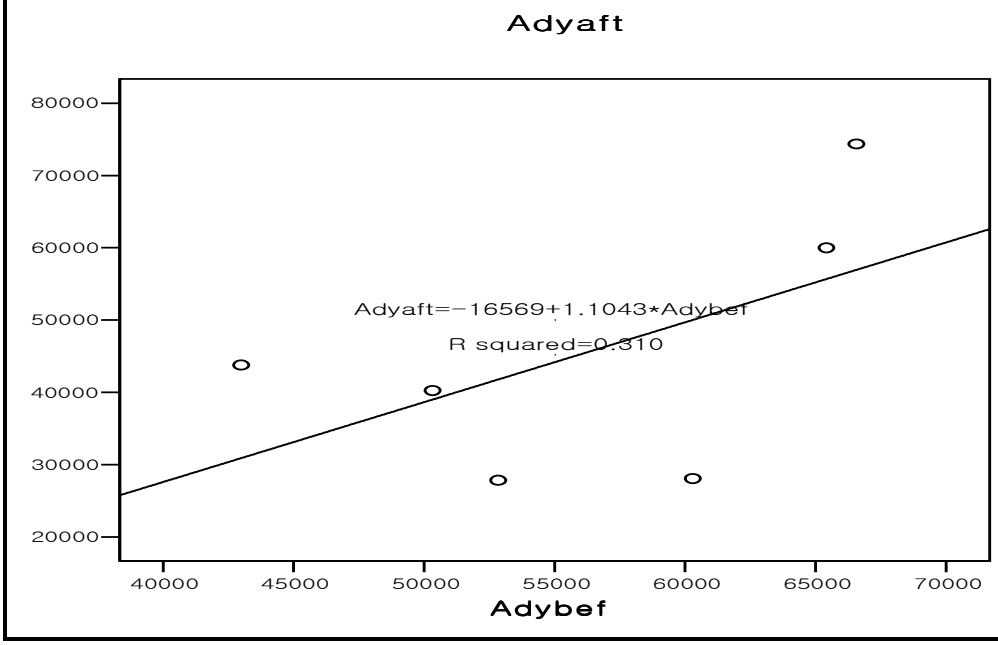

Fig. A.13 Accident correlation model by area type and daytime factor characteristics

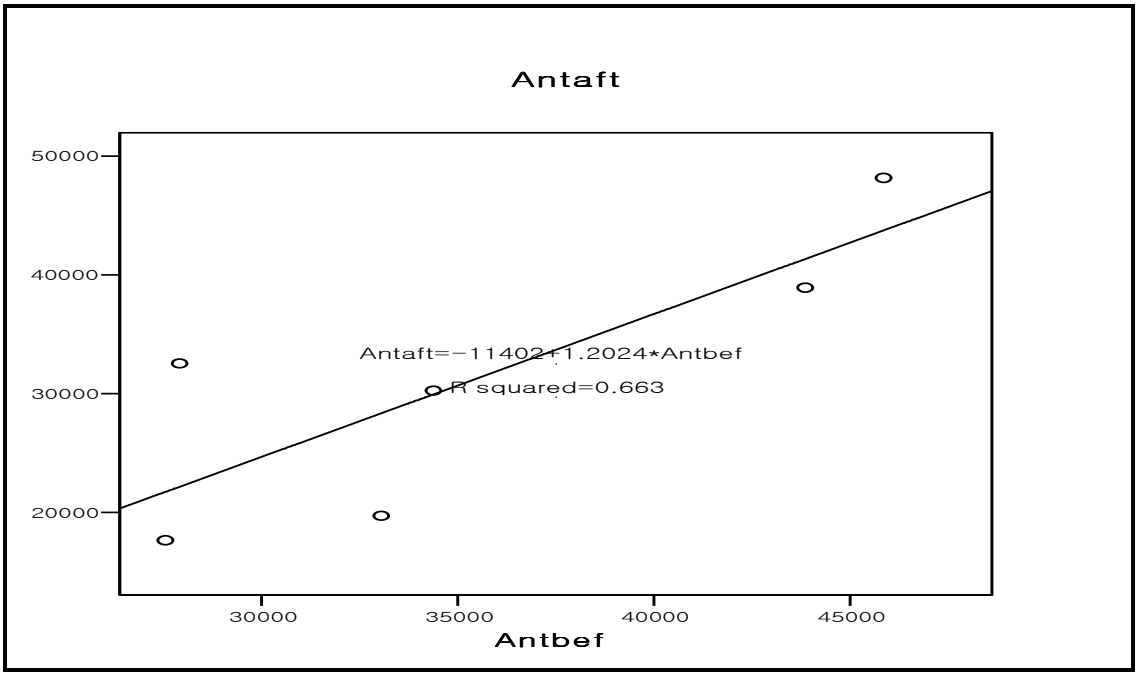

Fig. A.14 Accident correlation model by area type and nighttime factor characteristics

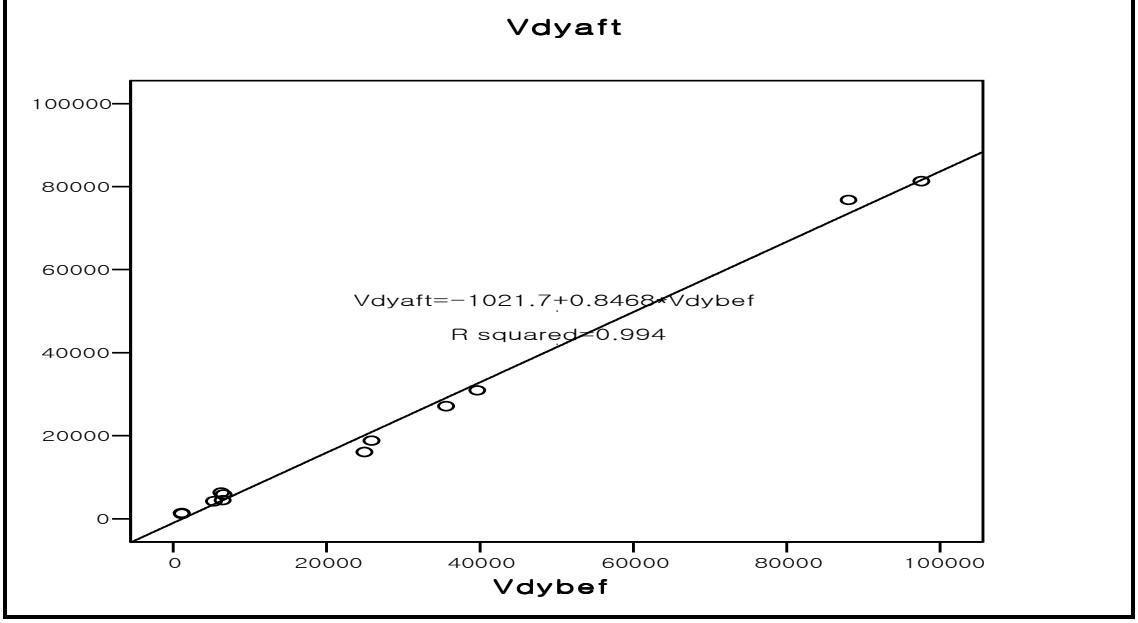

Fig. A.15 Accident correlation model by vehicle type and daytime factor characteristics

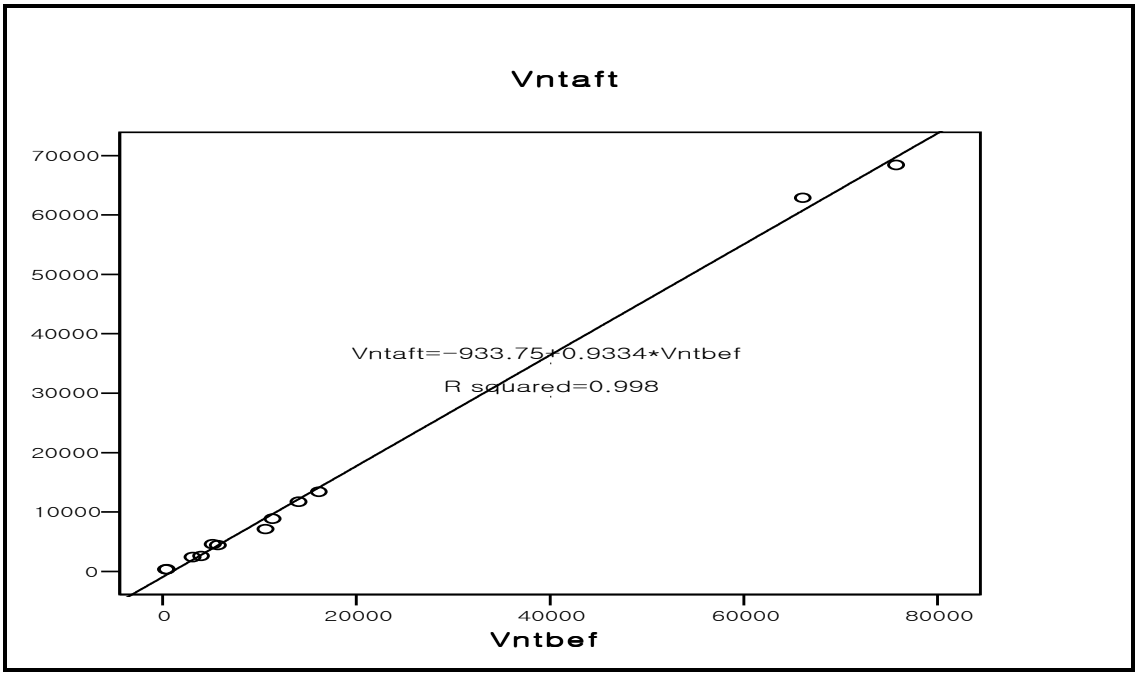

Fig. A.16 Accident correlation model by vehicle type and nighttime factor characteristics

Appendix B

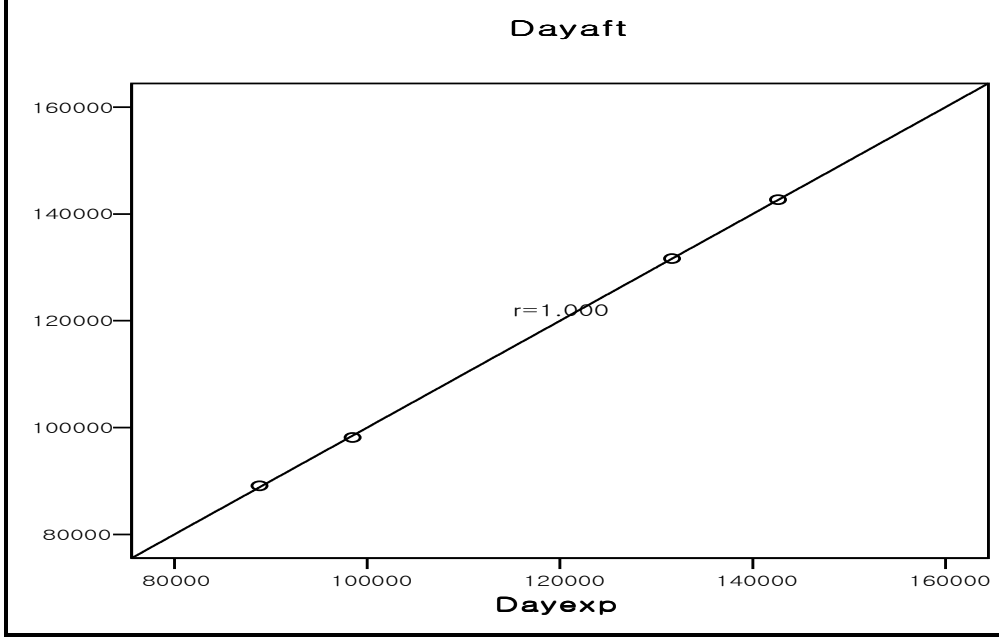

Fig. B.1 Correlation between the observed and expected accidents by day-and-night factor characteristics

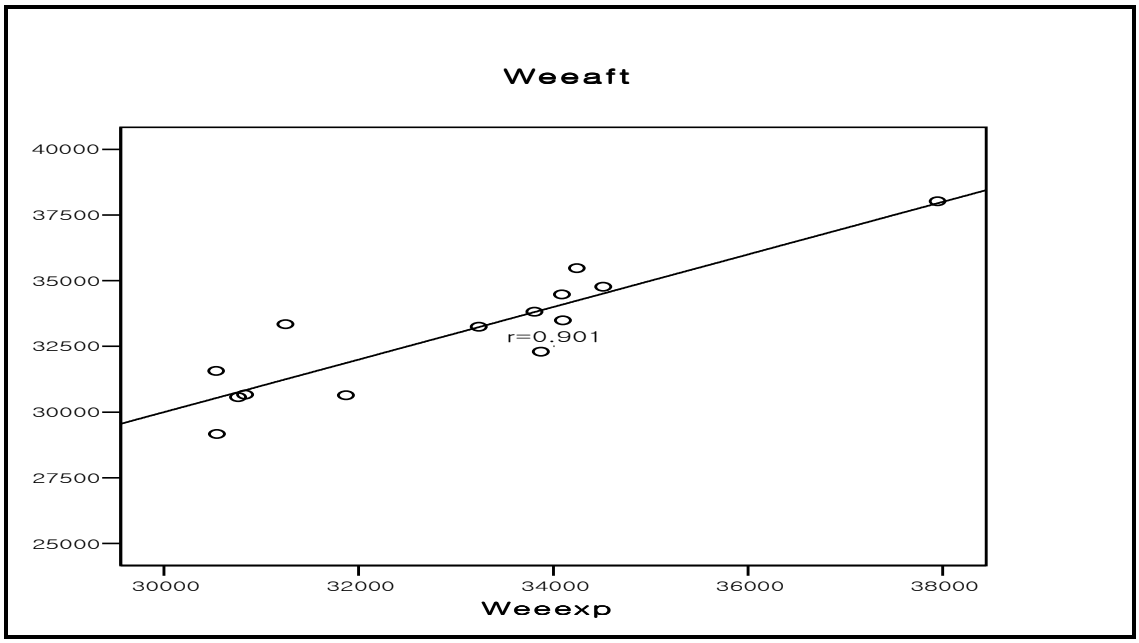

Fig. B.2 Correlation between the observed and expected accidents by weekday factor characteristics

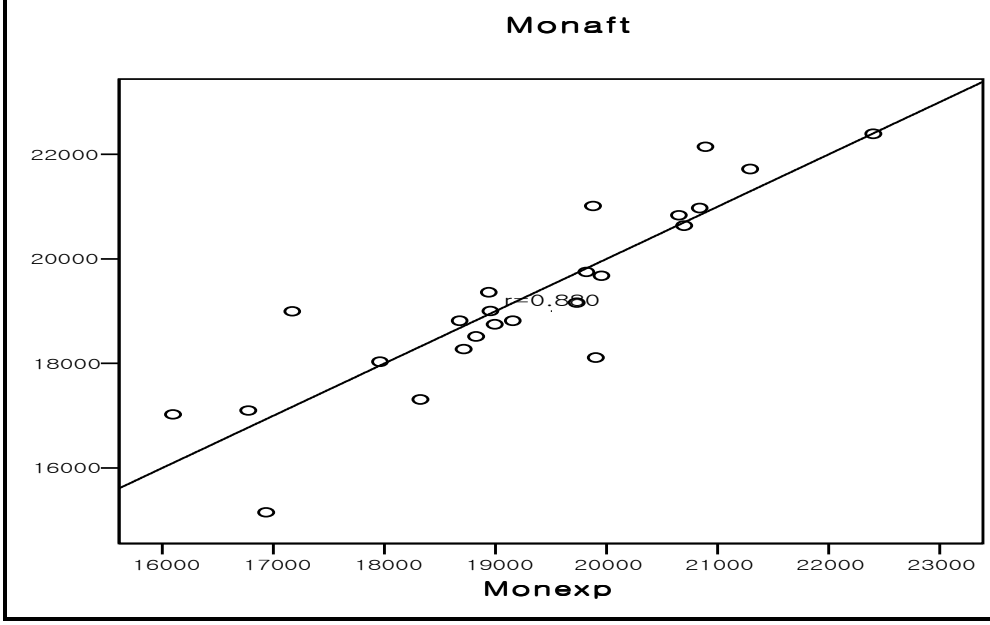

Fig. B.3 Correlation between the observed and expected accidents by monthly factor characteristics

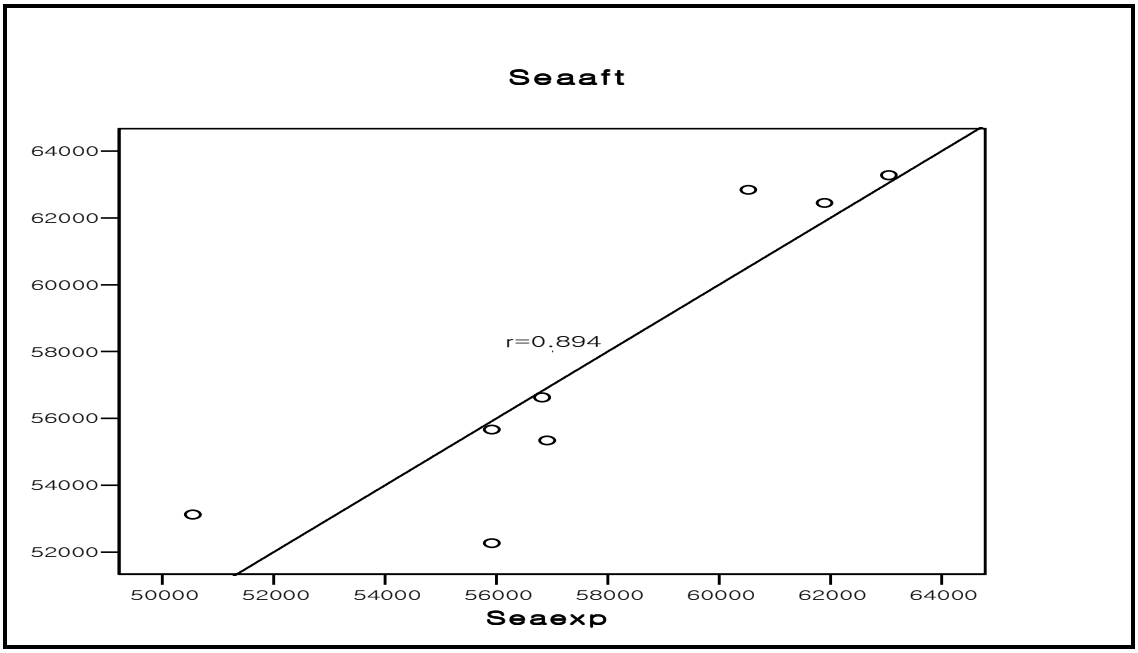

Fig. B.4 Correlation between the observed and expected accidents by seasonal factor characteristics

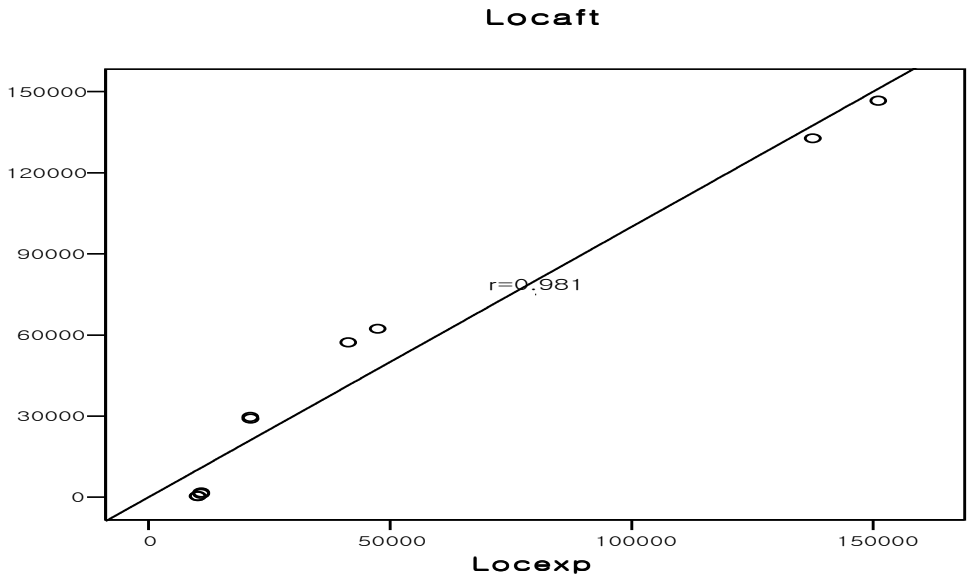

Fig. B.5 Correlation between the observed and expected accidents by location factor characteristics

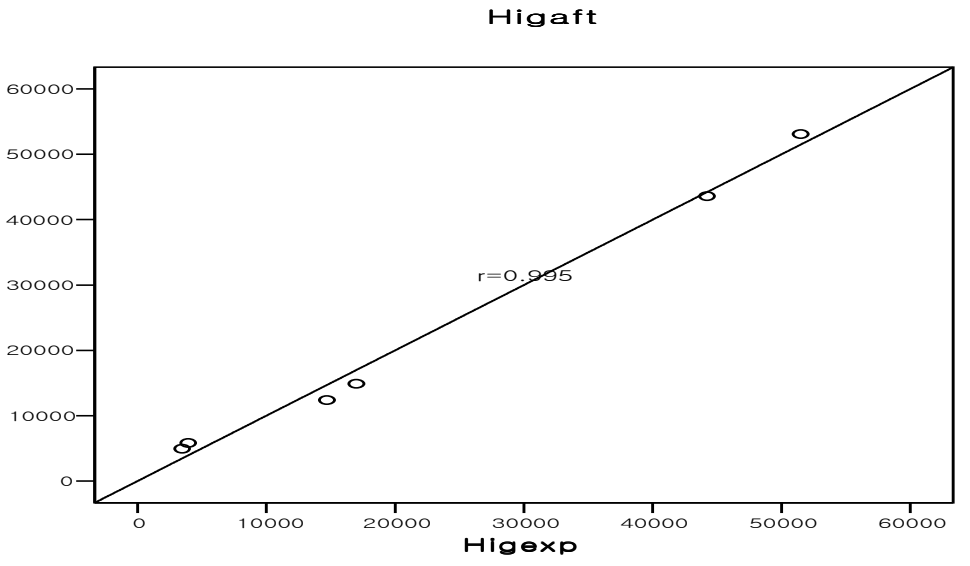

Fig. B.6 Correlation between the observed and expected accidents by road type factor characteristics

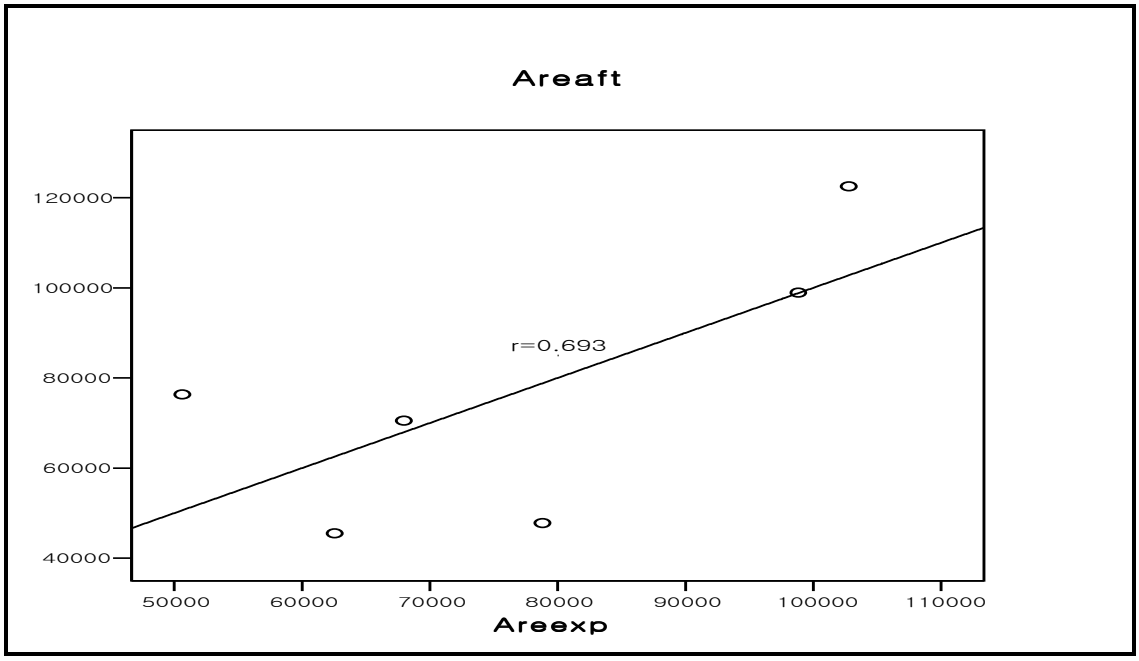

Fig. B.7 Correlation between the observed and expected accidents by area type factor characteristics

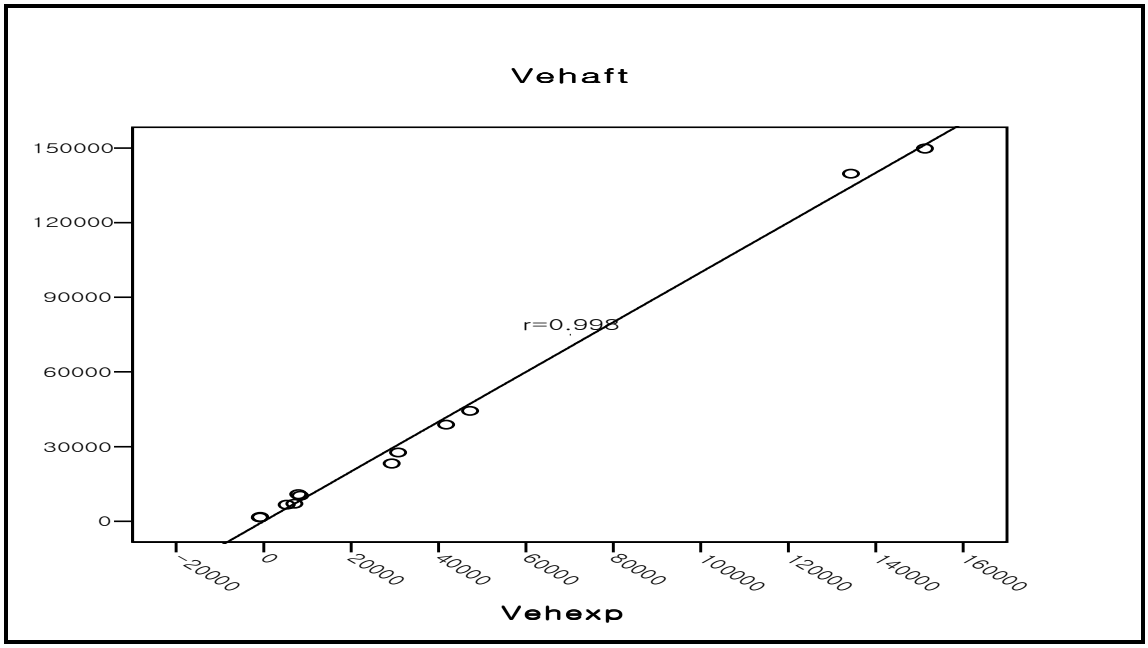

Fig. B.8 Correlation between the observed and expected accidents by vehicle type factor characteristics

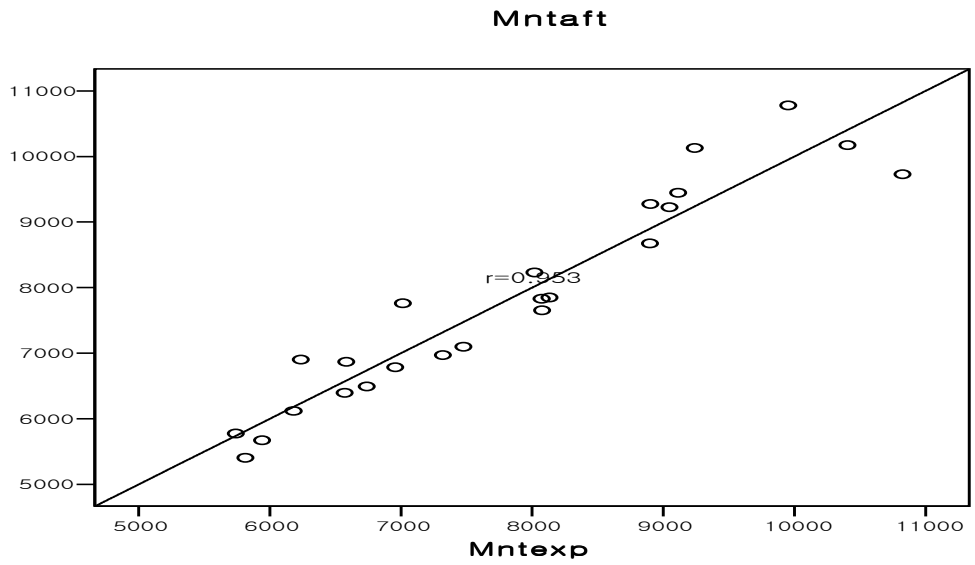

Fig. B.9 Correlation between the observed and expected accidents by month and nighttime factor characteristics

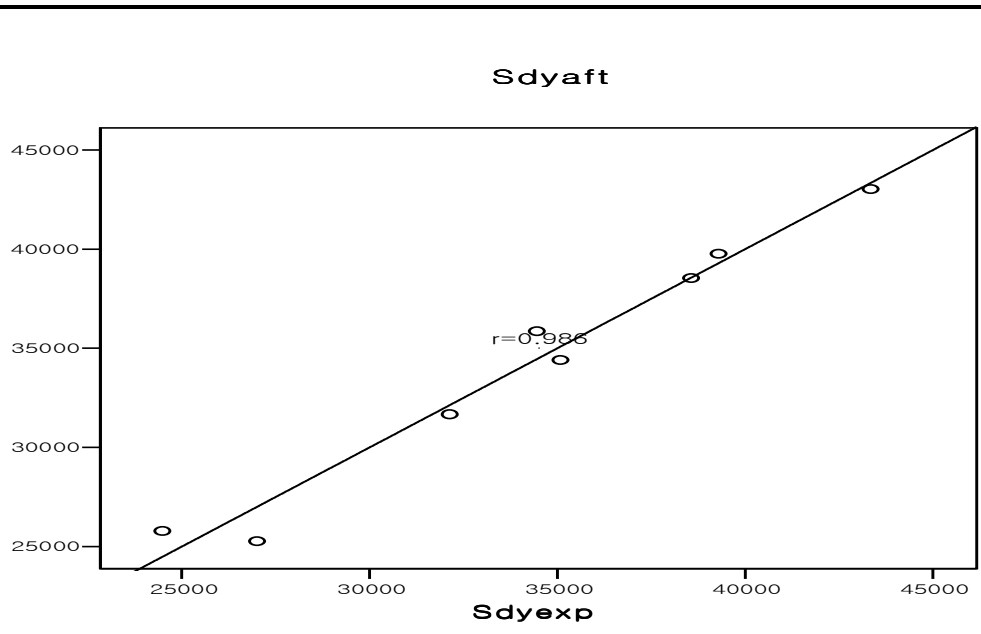

Fig. B.10 Correlation between the observed and expected accidents by season and daytime factor characteristics

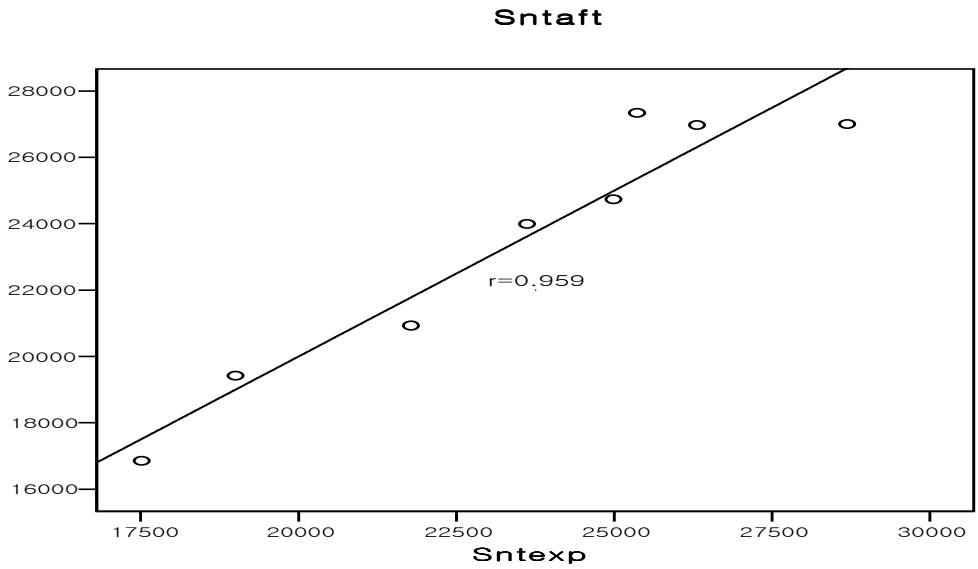

Fig. B.11 Correlation between the observed and expected accidents by season and nighttime factor characteristics

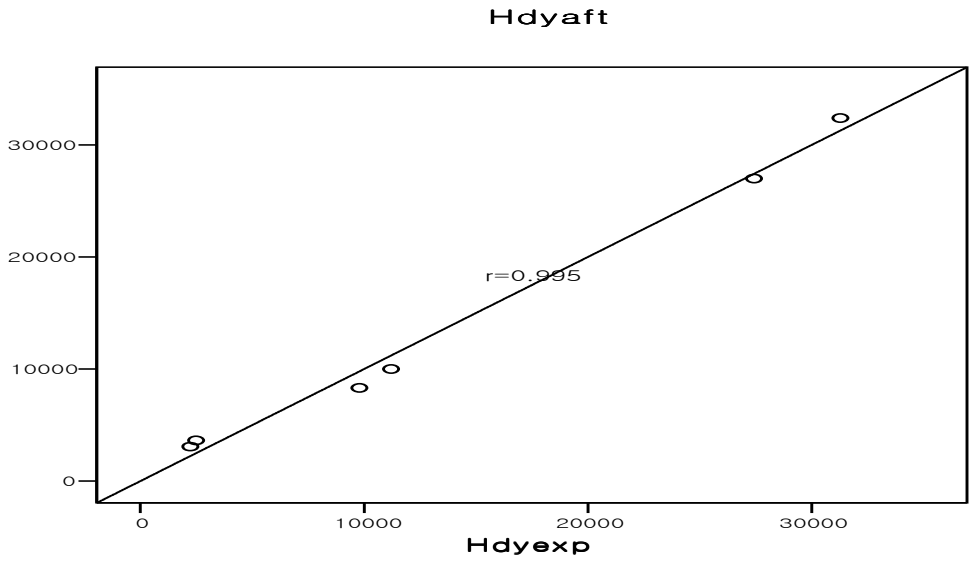

Fig. B.12 Correlation between the observed and expected accidents by road type and daytime factor characteristics

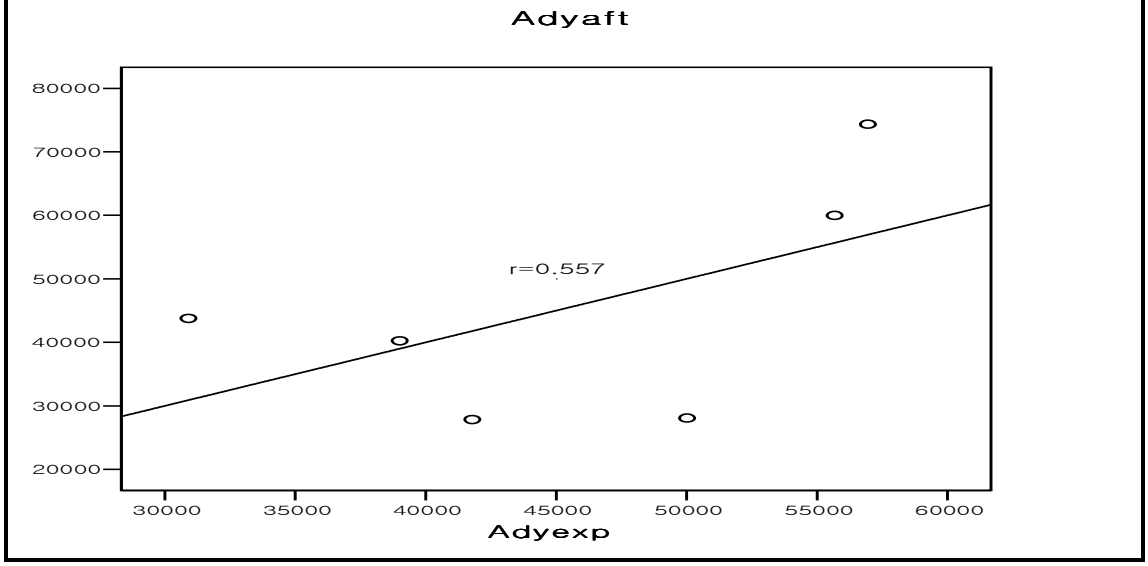

Fig. B.13 Correlation between the observed and expected accidents by area type and daytime factor characteristics

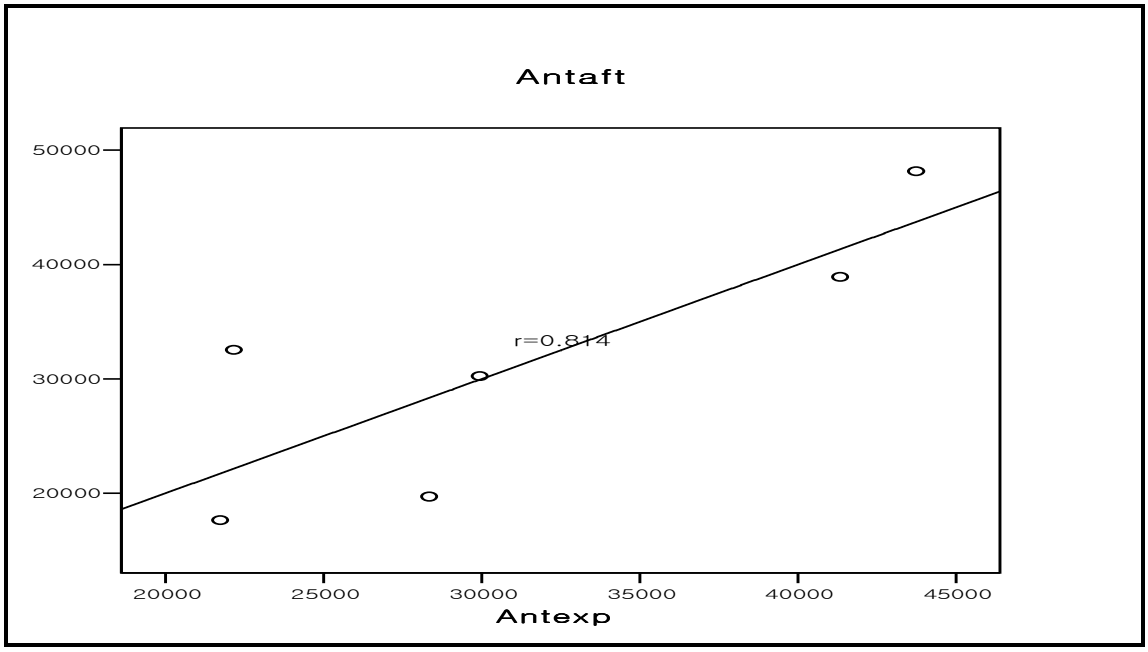

Fig. B.14 Correlation between the observed and expected accidents by area type and nighttime factor characteristics

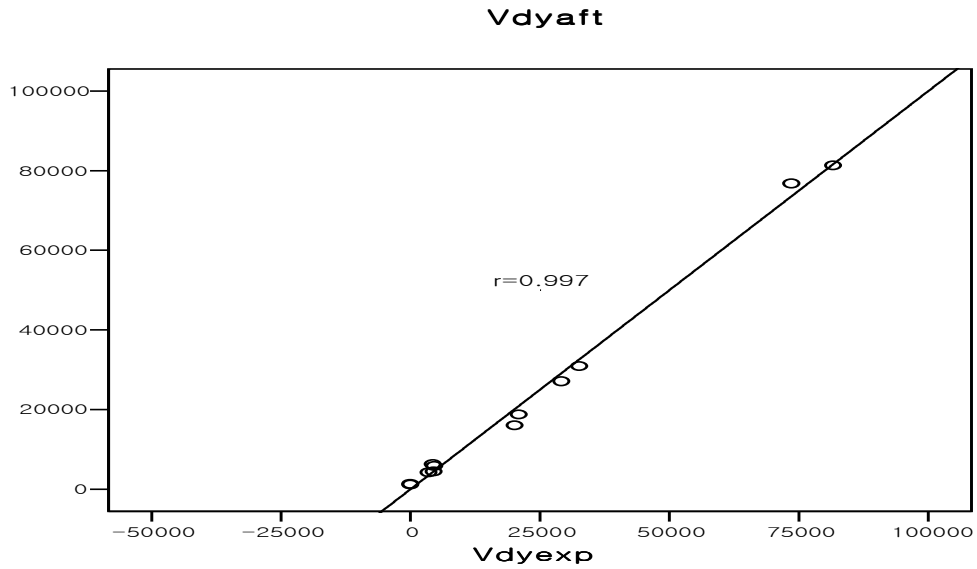

Fig. B.15 Correlation between the observed and expected accidents by vehicle type and daytime factor characteristics

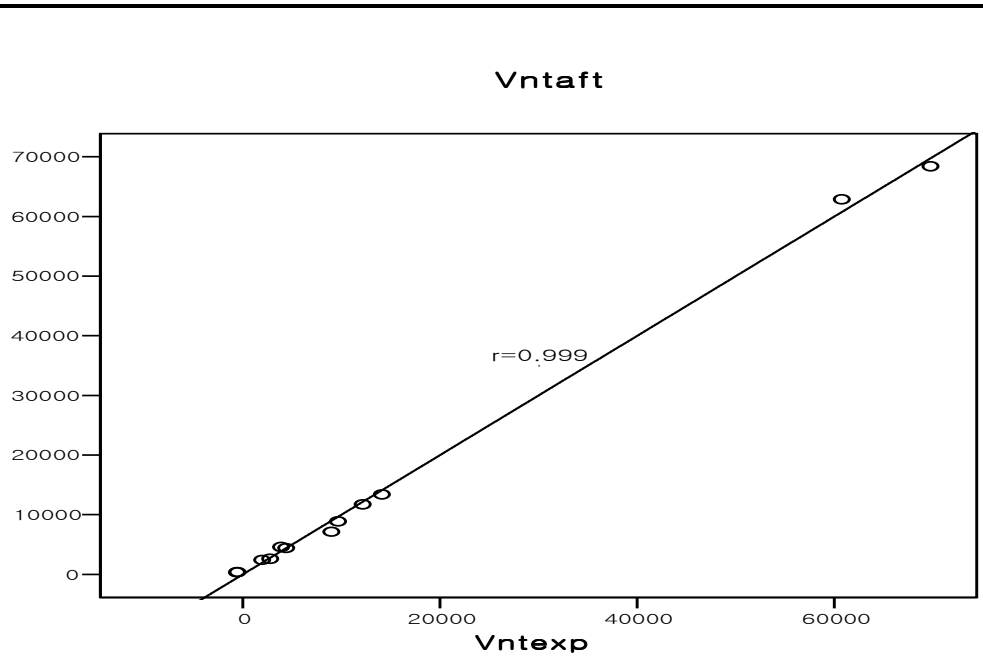

Fig. B.16 Correlation between the observed and expected accidents by vehicle type and nighttime factor characteristics