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Identification of Hazardous Location Using Information System Application

Abstract

This research examined the effect of the adverse conditions on the traffic accidents along the First Stage Expressway. To facilitate the process of hazardous locations identification, this study utilized the Rate Quality Control Method through the means of package development. Base on this application, the analysis of is applied to input and analyzed the meteorological information and together with traffic accident information can be performed. Furthermore, the results of identification hazardous location based on adverse condition are also friendly demonstrated by the use of Geographic Information System (GIS). The results indicate that more number of hazardous locations existed on the circumstance of accident data associated with adverse condition than normal condition. Evidence on safety issue subjected to expressway accident data could be useful to raise the awareness of concern authorities about adverse conditions impact on hazardous location.

Keywords Traffic accident, Hazardous location, Geographic Information System

1. Introduction

One of the problems to determine the relationship between climatologically conditions and traffic accidents is the relatively infrequent occurrence of accidents attached with the rapid change

in weather over short period of time. It is difficult to perform investigation to actually correlate of each factor. Another problem is the number of variables, which might contribute to traffic accidents.

Not only are rainfall, but light conditions are all important(1).

This research examined the effect of the weather conditions on the traffic accidents. The variables of this research are not available in directly usable form. Besides the data are not coding in the computerized form. This problem makes it much more difficult to analyze and collect the data. The accessible in computerized form provide many advantages in excess of the hardcopy form. Consequently the package development of database and GIS technique is considered as the tools of processing in this research.

2. Study Area

In order to reach the objectives of this research, the First Stage Expressway was selected as the study site as shown in Figure1. This expressway was chosen because of the availability of accident data and the traffic along this first stage expressway.

Figure 1 Study area: First Stage Expressway

3. Methodology

This research investigated weather conditions relate to traffic accidents. The area of study is the First Stage Expressway in Bangkok. The information composes of two sets of the data. The traffic accident information were obtained from the Expressway and Rapid Transit Authority of Thailand (ETA) and the meteorological information were collected by Thai Meteorological Department (TMD).

3.1 Package Development

This developed package can be used as a guideline for the investigator in data collection stage. The developed package can also be used in studying the adverse conditions related to accidents. This developed package can assist in analyzing and presenting results of the findings. Specifically, the package aim to

- provide a computerized system to store and manipulate data that are required to collect.
- analyze the collected data.
- update the existing data and also to insert new data on the user friendly interfaces.

The package was developed under Microsoft Access on the application of the Microsoft Visual Basic. The data were divided into two sets as ETA traffic accidents data and Meteorological data. The developed database system combines the ETA accidents data and weather factors data together, which is designed to store and manage information obtained from the both ETA and TMD. User interface is recognized to be friendly and simple. PC- based software is written to support these mentioned tasks.

3.1.1 Entity Table

Tables are collection of records that separate into two sets as ETA accidents table and meteorological table as shown below:

ETA Accidents table (Acc. Id, Acc. Code, Expressway Name, Date, Time, Location, Station, Location Detail, From, To, Lane, Acc. Characteristic, ETA property damage, Damage cost, Vehicle#, Injury#, Fatality#, Weather con., Surface con., Geometric, Building, Sign, Clearance, Obstacle, Driver characteristic, Vehicle con., and Driving characteristic.)

Meteorological tables

Rainfall table (Date of observation, Time of observation, every 24 hr. interval)

Humidity table (Date of observation, Time of observation, every 24 hr. interval)

Cloud table (Date of observation, Time of observation, every 24 hr. interval)

Temperature table (Date of observation, Time of observation, every 24 hr. interval)

Pressure table (Date of observation, Time of observation, every 24 hr. interval)

Visibility table (Date of observation, Time of observation, every 24 hr. interval)

Radiation table (Date of observation, Time of observation, every 24 hr. interval)

Wind speed table (Date of observation, Time of observation, every 24 hr. interval)

3.1.2 Query

Query is a tool to find the selected information that linked between the ETA accident information and meteorological information such as weather conditions related to accidents query (Date, Time, Accident Detail, Meteorological Detail).

3.1.3 Forms

Forms are designed from tables and queries. Because the forms can communicate between users and data, it is possible to use with computer to understand, perform and interpret. The forms

are comprised of Main menu form, Introduction form, Accidents input form, Accidents data editor form, Meteorological database form, Meteorological factors selection form, Meteorological input form, Meteorological factors form, Accident prediction equation form, Hourly accident prediction form, and Daily accident prediction form.

3.1.4 Reports

Reports can display the output of the records, it provides the information that the user has designed to format or group the information including sum, minimum, maximum, and average. Reports comprise of Summary of accident report, Accidents link to Weather report, and Summary of Meteorological factors report.

3.2 Identification of hazardous location based on adverse conditions

This analysis is defined the severity index as an economic losses of those victims. The economic losses have been used in term of monetary. Dead person, injury person and property damage can be transferred to monetary term. In this study selected Kao's formula(2) to evaluate the severity index for the First Stage Expressway. The severity index was used to identifying the hazardous locations along the First Stage Expressway. The steps in identifying the hazardous locations are as follows:

1) Calculated the severity index rate for each station of the First Stage Expressway.

2) Calculated upper limit and lower limit for each station by using RQCM method.

3) Compare between the severity index rate and the limit value of the RQCM method.

4) Compare the results of each condition that related to the weather effects.

Identification of the character of each section is done by comparison of the severity index rate with these upper and lower limits. The sections lengths (500 m.) were also classified to A-section and B-section as Northbound direction and Southbound direction respectively. If one section's severity index rate is dropped within the range between the critical upper and critical lower levels, this section is classified as "Normal" section. If it locates outside the range by less than the lower limit, it can be classified as "Safety" section. On the other case, if it falls outside the range by grater than the upper limit, it is Hazardous section. The results of each condition such as accident related to rainy condition, light conditions and both of them are compared to determine the effects of weather conditions on the traffic accident.

3.2.1 Severity Index

The severity index can be described as economics losses of those victims. The economic losses have been used in term of monetary. The monetary value of the person who was saved from the fatality and prevented from injury and of the property prevented from damage by implementation of the traffic safety plan were considered as benefits(3). Dead person, injury person and property damage can be transferred to monetary term. The severity index formula by using the equivalent property damage is illustrated in Equation 1.

$$SI = \frac{(W_f * F + W_j * J + PDO)}{T} \qquad (1)$$

Where SI = severity index, W_f = fatality weight, W_j = injury weight, F = fatality, J = injury, PDO = property damage only, T = total case of accident

The data used for Japan International Cooperation Agency (JICA) analysis obtained from Auto Subcommittee of the General Insurance Association of Thailand and from the traffic police(3). Kao applied values for weighting of the accident unit into Equivalent Property Damage Only (EPDO) by using the results of JICA benefits study for Bangkok traffic accidents as shown(2):

Fatality	=	45
Injury	=	4.5
Property Damage Only	=	1

3.2.2 Accident Statistic Methods

The Rate Quality Control Method is the one of the accident statistic method. The rate quality control could be used to identify hazardous locations. This method can be calculation of the accident rate at each location. Furthermore, a statistic test could determine if that accident rate at location was significantly higher than accident rate of other location with similar characteristics. The statistic test was based on the Poisson distribution. For each location, the upper limit and lower limit of accident rate were calculated as described by Zegeer[4].

$$\text{U.L.} = R_a + k * \sqrt{\frac{R_a}{M}} + \frac{1}{2M} \qquad (2)$$

$$\text{L.L.} = R_a - k * \sqrt{\frac{R_a}{M}} - \frac{1}{2M} \qquad (3)$$

Where U.L. = critical upper limit of accident for a spot (accidents per million vehicles) or section (accidents per million vehicle miles). L.L. = critical lower limit of accident for a spot (accidents per million vehicles) or section (accidents per million vehicle miles). R_a = average accident rate for all spots similar characteristics. M = million of vehicle passing

over spot in the study period. *k* = a probability factor determine by the designed level of significant.

A probability level was select to assure that an accident rate was sufficiently large so that it could not be reasonably attributed to random occurrence. Selecting confidence level (high value of *k*) results in fewer locations being identified as having critically high accident rate(5).

3.3 GIS development

The data were obtained from the data collection step. These acquirement data were reformatted for the purpose of the geographic information system. The designed database can be classified into two types as follows:

1) The attribute data

The attribute data were the accident data that were directly involved with the identification of the hazardous locations. The reformatted data include number of fatality, injury and property damage records along each section of the First Stage Expressway. The attribute data that were used in this research composed of as follows:

- Station identification
- Traffic volume
- Vehicle-Kilometers
- Number of accident case
- Number of fatality
- Number of injury
- Number of Property damage only

2) The Spatial data

The spatial data are the geographic data. It was used on the part of the digitizing to create the arc file. The geographic data were obtained as follows:

- Road network map
- Expressway map
- Station Location
- Road Marking detail
- Geometric Picture
- Location picture

The GIS database is including identification of hazardous locations, additional photographic images, density of the accidents related to weather conditions. This software is capable to run on Microsoft Window; therefore, the evaluations are possible done for identification hazardous location.

Based on data from September 2000 to August 2000, the results of comparison are displayed on the geographic format that can easily to understand the effects of weather conditions related to hazardous locations. Not only the hazardous location that can be displayed on the ArcView software, but the general information and

picture of the First Stage Expressway can be also the displayed.

4. Developed package

This study also developed the database management system. The data were divided into two sets as ETA traffic accidents data and Meteorological data, which related data have to be prepared appropriately and effectively. The data of study should be correctness, and consistency, so that the amount of redundancy can consequently be reduced, in that way to save resources and reduce the inconsistency of the information.

Consequently, this developed package intended to simplify the process of data operation for the user to examine the effect of weather factors on traffic accident along the First Stage Expressway. To make use of graphical user interfaces, the user can operate with accident data and meteorological easier. User interfaces can provide tools for user to contract with information. The selected data would be presented using interfaces tool as text and tables.

Within the interfaces, Menu is a tool that provides user to operate with the data as shown in Figure 2. To make use of graphical user interfaces, the user can operate with accident data and meteorological easier. User interfaces can provide tools for user to contract with information. The selected data would be presented using interfaces tool as text and tables. The main menu form consists of seven buttons to link with the various applications such as introduction, ETA Accident Database, Meteorological Database, Report, GIS, Accidents prediction and Exit.

Forms are designed from tables and queries, and communicate between users and information, it is possible to use with the computer to understand, perform and interpret. The example of forms can be shown on Figure 3 and 4.

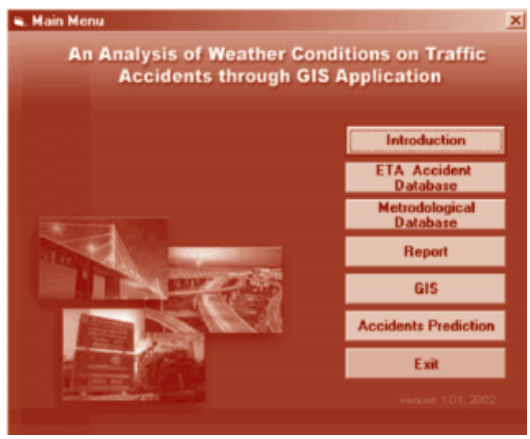

Figure 2 User interface

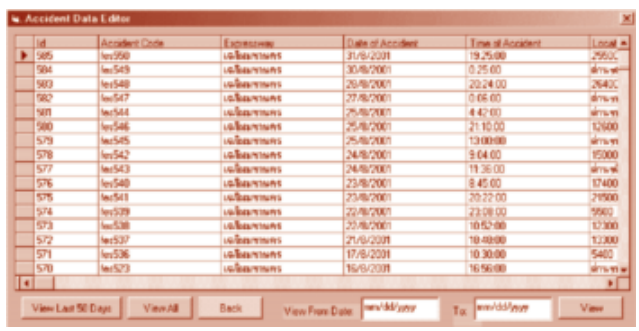

Figure 3 Accident Data Editor

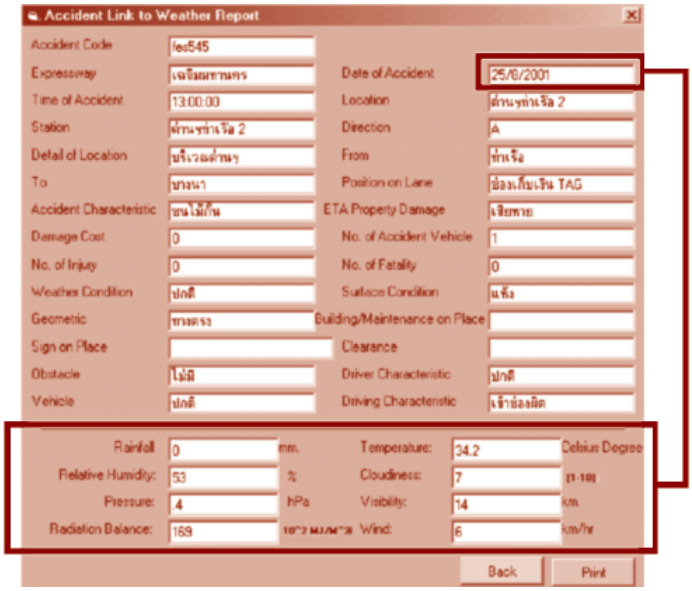

Figure 4 Accident Link to Weather Report

The database management system should validate data before permitting it to be stored in the database, and should provide comprehensive recovery procedures. The designed package is made available to warn user to know when entering erroneous data. The notice box would be shown as a warning system when incorrect type of value is entered. The example of validation is presented in Figure 5.

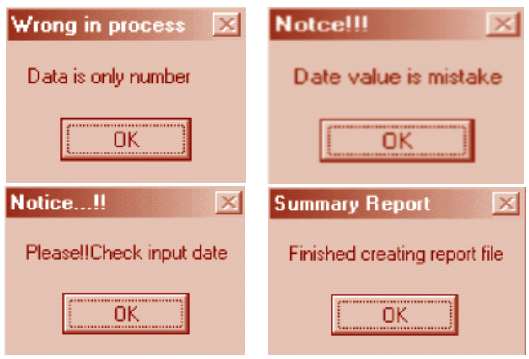

Figure 5 Notice Box for warning

5. Identification of Hazardous Location

Once the severity index and severity index rates can be determined, then by using the traffic information obtained and applying the rate quality control method (RQCM), hazardous locations along the First Stage Expressway are identified. It was known that among the 31 kilometers length of the expressway. The locations of identification were separated into 62 sections by 500 meters section length. The sections lengths were also classified to A-section and B-section as Northbound direction and Southbound direction respectively.

However, there are 10 locations classified as hazardous locations in this study year. The total number of hazardous locations of Northbound direction were 6 locations namely: A180, A220, A275, A285, A295, and A310, while 4 locations were found on Southbound direction namely: B130, B175, B225, B285 (i.e. A180 means Northbound at km. 18+000 and B175 means Southbound at km. 17+500).

The hazardous location of section A295 is located over the end of the First Stage Expressway in the direction A. At this location, particular waving of traffic

movements is expected as the traffic have to divert either to the left lanes loading forward to other provinces or to the right lane to Dao Khanong area. The hazardous location of section A220 is located over the exit ramp, which contributed diverging conflict. The hazardous location of section A180, A310 is located at the end of the First Stage Expressway in the direction A.

At this location, particular waving of traffic movements can expect, as the traffic has to merge with the Highway road. High volumes of heavy trucks and automobiles can also be expected as the end of the Expressway leads toward various factories and number of residential areas. With these possible conflicting movements of weaving and high traffic volumes, particularly heavy trucks, high severities of accidents has occurred. The hazardous location of section B175, B225 is also located at the entrance ramp. Then, the accident could occur when the vehicle merge on the main route. However, the others location is placed on the main expressway.

Furthermore, the result of identification of hazardous locations based on adverse conditions can be calculated under 6 conditions; general condition, rain condition, day time condition, night time condition, day time with rain condition, and night time with rain condition. Table 1 shows the example of hazardous location based rain condition. The results of identification of hazardous locations are shown in Table 2.

Table 1 Hazardous Location of 500 m. section length on the First State Expressway (rain condition)

Station	Lth. (m.)	Traffic Volume (mv)	Exposure (MVK)	Severity			PDO	Total accident case	Severity Index	Severity Index Rate	Upper Limit	Lower Limit	Evaluation
				PDO	Injury	Fatality							
A005	500	29.17	14.59	0	0	0	0	0	0.000	0.000	0.203	-0.099	Normal
A010	500	29.17	14.59	0	0	0	0	0	0.000	0.000	0.203	-0.099	Normal
A015	500	29.17	14.59	0	0	0	0	0	0.000	0.000	0.203	-0.099	Normal
A020	500	29.17	14.59	0	0	0	0	0	0.000	0.000	0.203	-0.099	Normal
•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•
A050	500	55.64	27.82	7	2	0	0	1	9.000	0.324	0.155	-0.051	High
A055	500	55.64	27.82	0	0	0	0	0	0.000	0.000	0.155	-0.051	Normal

Table 2 Hazardous Locations of each weather conditions

Conditions	Hazardous Locations	
	Northbound direction	Southbound direction
General condition	A180, A220, A275, A285, A295, A310	B130, B175, B225, B285
Rain condition	A050, A065, A100, A125, A210, A235, A260	B035, B045, B105, B165, B260, B275
Day time condition	A220, A265, A295, A310	B105, B130, B215, B235, B240, B255, B285
Night time condition	A145, A170, A180, A210, A260, A275, A280, A285	B105, B110, B125, B170, B175, B210
Day time with rain condition	A050, A065, A125, A210	B105
Night time with rain condition	A100, A210, A215, A235, A260	B030, B045, B060, B105, B115, B165

To compare among conditions, this study found that the number of hazardous location associated with rain are greater than the number of hazardous locations associated with general condition, the number of hazardous location associated with day time are less than the number of hazardous locations associated with night time, and the number of hazardous locations associated with day time with rain are also less than the number of hazardous locations associated with night time with rain.

Therefore, the adverse conditions affected on the number of hazardous location, due to the fact that the number

Figure 6a The display of GIS

Figure 6b The display of GIS

of injury occurred with adverse weather is higher than the number of injury with general condition, and severity index rate give the weight for injury and fatality is higher than weight for PDO. The severity index rate with adverse weather is higher

Figure 7 The accident spot map and accident density map

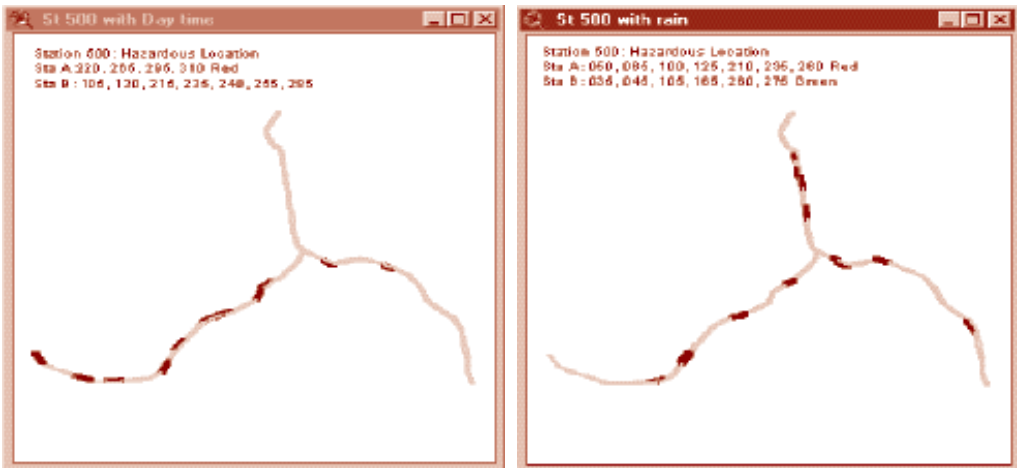

Figure 8 The example of hazardous location

map is defined as low density, medium density, high density, and very high density. The accident spot map and accident density map are shown in Figure 7. The results of identification of hazardous location are shown in Figure 8.

7. Conclusion

This research developed and simplified the package of information system. This developed package can be used as a guideline for the investigator in data collection stage. The developed package can also be used in studying the adverse weather conditions related to accidents. It contains the meteorological information and accidents information. The package also endows with the accident prediction that can calculate the number of accident case. The package was developed under Microsoft Access on the application of the Microsoft Visual Basic that can also

store and manage information obtained both from ETA and TMD. Geographic Information System was linked to this developed package to display the result of analysis of weather conditions related to accidents. It was applied to input and analyzed the meteorological information and traffic accident information.

There are 10 locations classified as hazardous location in this study year, the total number of hazardous locations of the Northbound direction has 6 locations, while 4 locations were found on the Southbound direction. Furthermore, the results of identifying the hazardous locations based on weather conditions can be calculated within 6 conditions such namely: general condition, rain condition, day time condition, night time condition, day time with rain condition and night time with rain condition. To compare among conditions, when high number of injury often occur, with an adverse weather condition, then Severity Index Rate indicates high value. This study found that the number of hazardous locations associated with adverse weather are greater than the number of hazardous locations associated with general condition.

8. Recommendation

This study preferred to state the recommendations to researchers concerned in traffic accidents, which are expected to be useful for further studies. The recommendations are listed as follows:

In order to find the accurate effect of the weather condition of accidents, both the ETA and TMD should come up with a connection to be aware about the traffic safety. It is recommended to set up the equipment such as weather radar, weather-measured instrument for calculations, etc. to the places that accidents often occur.

Further study, the real-time weather information must be used as Intelligence Transportation System to provide the benefit information and protect the road safety for the road user.

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