Estimation of Disaster Influence on Transportation Mobility


Abstract—Traffic damage during a disaster is very different according to disaster’s class, size and traffic management strategy. Therefore traffic management during a disaster is needed to embody according to disaster situations of variety. In this study, through GIS program which is spatial analysis, we investigated disaster decline depending on the degree of each situation and designated disaster influence in aspect of transportation. In disaster, we analyzed the change of travel time from origin-destination traffic flow. In addition, we set the transportation disaster influence for checking the effects by each link. The research implemented with using 4 scenarios in Seoul Metropolitan area. In analysis result, the case 3, where 3rd link had been cut off, had the worst and widest influence on the area. In case of cutting link in direction of height, the disaster had an impact on South-North axis. Similary, when the link was cut in direction of crosswise, most of transportation disaster influence was generated on east-west axis. The average numerical value of mobility decline was the highest in the order of Yeoksam-1dong, Yeoksam-2Dong, Seocho-3dong and Samsung-2dong in Seoul Metropolitan area.

Keywords—Disaster, Disaster Influence, GIS program, The characteristics of disaster, Traffic management strategy.

I. INTRODUCTION

A. Background of the study

Recently traffic management strategy during a disaster is very important from around the world. Real life situations like floods, hurricanes, chemical accidents, nuclear accidents, terror attacks and other events may occur which threaten the life and the health of human beings. (S. Bretschneider, A. Kimms, 2011)[1] Under these circumstances, in the case of a disaster, response lack of traffic management aspects is caused massive damage to life, property, vehicles and pedestrians.

Disaster in human life gives various damages. When traffic facility capacities are declined by disaster, it should happen many problems. One case, society cost are increased when some products and people move. That's why traffic management strategies are important and we should cover all disaster which support natural damage and come up with an effective plan.

B. The purpose of the study

Traffic damage during a disaster is very different according to disaster’s class, size and traffic management strategy. Therefore traffic management during a disaster is needed to embody according to disaster situations of variety.

To get back loss of traffic function by the disaster, we need an effective counterstrategy to situation. But before that, we need to set up proper transportation disaster influence.

In this study, through GIS program which is spatial analysis, we investigated disaster decline depending on the degree of each situation and designated disaster influence in aspect of transportation. Based on the set of influence range, specific and realistic traffic management strategies during a disaster will be prepared. Through the study, we wish reducing social costs by disaster.

C. Scope of the study

In this study, only road traffic among the wide transportation means (airport, road, track etc) was involved in only part of the study. The flow of research is Fig. 1 of below.

Fig. 1 Flow of research

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II. REVIEW PREVIOUS STUDIES AND THEORY

A. Previous Studies

A Study for the Introduction of Snow Removal System in Inter-city Roads (National Institute For Disaster Prevention, 2003) showed preparing for the damage caused disaster due to heavy snowfall in winter. In addition, this study covers improvement of highway management system [2].

Improving Transportation Disaster System in Seoul (Sung-ill Shin, 2006) suggests how to handle traffic function when it rains. It is using an automatic check of approach ramp if expressway floods [3].

An effective Strategy for Expressway Snow Removal Considering Traffic Congestion Costs (Yun-ji Baek, 2010) showed method of reducing travel time cost all roadways to do snow removal operations immediately when roadway is closed by heavy snow [4].

Strategies of national transportation research(Korea Research For Human Settlements, 2005) analyzed problem of disaster confrontation system and shows phased strategy concretely to solve it [5].

B. Study on Theory

Disaster: what a disaster is a situation resulting from an environmental phenomenon that produced personal injury, physical damage, or harm to nation by typhoon, flood, heavy rain, strong wind, wind and waves, tsunami, heavy snow, lightning, drought, earthquake, yellow dust, red tide. Natural disaster is caused by typhoon, flood, heavy rain, strong wind, wind and waves, tsunami, heavy snow, lightning, drought, earthquake, yellow dust, red tide, so on.

The characteristics of disaster: disaster occurs sporadically and has a strong impact. In addition, disaster has a broad range of shapes and sizes. The possibility of occurrence and any change in circumstances is difficult to predict.

Disaster Influence: influence is a location effected by traffic and can separate direct influence and indirect influence. Direct influence is disaster risk which is damaged by disaster directly. Moreover the congestion in the indirect influence gets worse cause by car from direct influence, so it should control the traffic flow can't approach the direct influence.

In this research, supposing influence is the location that it takes more time to get their destination than usual. The location separate by level of mobility decline degree. In addition, each level should be managed in traffic aspect properly.

III. ANALYSIS METHOD

A. Analysis Direction

We planned specific and proper disaster management plan in different transportation disaster influence for effective response under the disaster. We applied the concept of mobility for estimating the influence range and analyze it using traffic flow and travel time. In disaster, we proceeded the research for maintain of normal level of traffic network and mobility recovery first.

B. Analysis Data

This research bases on Capital area O/D and network data from Metropolitan Transportation Authority. O/D data was analyzed 126zone among the whole country as 247 zone: 20 zone of Yongsan-gu, 20 zone of Sungdong-gu, 16 zone of Kwongjin-gu, 16 zone of Seocho-gu, 26 zone of Gangnam-gu, 28 zone of Songpa-gu and etc in Seoul Metropolitan area.

C. Analysis Method

We analyzed traffic flow and make a decision changed lead time as mobility decline degree compare analysis result to normal and link cut off.

In disaster, we analyzed the change of travel time from origin-destination traffic flow. In addition, we set the transportation disaster influence for checking the effects by each link. You can see Fig. 2. We researched the study based on 6 sections such as Yongsan-gu, Sungdong-gu, Kwongjin-gu, Seocho-gu, Songpa-gu, Gangnam-gu in Seoul Metropolitan area.

\[ M_d = \sum_j q_j \cdot t_j^d - \sum_j q_j \cdot t_j^b \] (1)

Equation (1) is mathematization of above concept. \(M_d\) is mobility decline degree by disaster. it is difference between the time of traffic flow in disaster and normal. \(q_j\) is traffic flow between origin and destination. \(t_j^d\) is travel time between origin and destination in disaster. \(t_j^b\) is travel time between origin and destination in normal.

We judged how decline the mobility of that area using the traffic flow and travel time difference in disaster and normal. Each area's region was separated by GIS program which is space analysis we investigated disaster decline degree according to each situation and designated transportation disaster influence.

D. Analysis Content

I set 4 highest demand links in Gang-nam gu. In addition, analysis was performed according to the presence or absence of links.
TABLE I
LINK PROPERTIES

<table>
<thead>
<tr>
<th>Item</th>
<th>Traffic Volume (pcu/h)</th>
<th>Design Speed (km/h)</th>
<th>Lane/Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>7,096</td>
<td>60</td>
<td>4/3300</td>
</tr>
<tr>
<td>No. 2</td>
<td>7,194</td>
<td>60</td>
<td>4/3300</td>
</tr>
<tr>
<td>No. 3</td>
<td>8,878</td>
<td>60</td>
<td>4/3300</td>
</tr>
<tr>
<td>No. 4</td>
<td>6,379</td>
<td>60</td>
<td>4/3300</td>
</tr>
</tbody>
</table>

Table I is the description for each link and Fig. 3 shows the location of the cut-link. In this study, selected each 4 links have 8 lanes and over 6,000 pcu/h.

IV. THE RESULTS OF THE STUDY

The maximum, average, standard deviation and the sum of the entire mobility decline degree values are shown in Table II. A range of impact was derived by GIS program for relative comparison of each scenario.

TABLE II
DEGREE OF MOBILITY DECLINE EACH SCENARIO

<table>
<thead>
<tr>
<th>Item</th>
<th>Maximum</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.1 link cut off</td>
<td>43.81</td>
<td>2.00</td>
<td>6.53</td>
<td>255.42</td>
</tr>
<tr>
<td>No.2 link cut off</td>
<td>36.35</td>
<td>0.99</td>
<td>4.62</td>
<td>114.37</td>
</tr>
<tr>
<td>No.3 link cut off</td>
<td>287.29</td>
<td>15.03</td>
<td>42.78</td>
<td>2202.47</td>
</tr>
<tr>
<td>No.4 link cut off</td>
<td>129.49</td>
<td>3.23</td>
<td>15.45</td>
<td>413.83</td>
</tr>
</tbody>
</table>

Table II shows degree of decline mobility each scenario, in case of No.1 link cut off represented maximum mobility decline degree 43.81 and 2.0 average. In addition, according to in case of No.1 link cut off, it showed total 255.42 of mobility decline degree.

In case of No.3 link cut off, maximum mobility decline degree was 287.29 and standard deviation value was 42.78. This case had the biggest mobility decline degree. Moreover, the case had the widest influence area among four cases. The results were analyzed No.3 link was the most important link among four cases.

Fig. 3 Analysis link

Fig. 4 In case of link 1 cut off

Fig. 5 In case of link 2 cut off

Fig. 6 In case of link 3 cut off
Shade displays degree of mobility decline at above figure using GIS program. Degree of mobility decline was established by 0 to 300 in each figure. The darker shade and higher mobility degree values the more mobility decline. Otherwise lighter shade and lower mobility degree values the less mobility decline.

Examining the Fig. 4 in case of link 1 out off, maximum mobility decline value was 43.81. In addition, the case had an effect on south region in black border around Gangnam-gu area.

In the case of link 3 out off of Fig. 6, mobility decline degree was exposed by numerical value of maximum 287.29. Effect of mobility decline degree by link cutting was represented that the case had an effect on east-west region in black border around Gangnam-gu area.

As well, mobility decline degree of maximum 129.49 was represented at case of link 4 out off of Fig 7. In addition, when disconnect link 3, it was showed that caused a lot of effects to east-west line.

When we examined the highest numerical value of mobility decline degree by each link disconnection, Yeoksam-1Dong was the highest by value of 116.68 and followed in the order of Yeoksam-2Dong 90.94, Seocho-Dong 63.95 and Samsung-2Dong 57.08.

The result of putting the analysis outcome together, the passing amount and mobility decline degree of road were not proportional necessarily. Late, we judged that we needed a research considering network circumstance of area surrounding or various special quality of road such as geometric structure on transportation disaster influence establishment.

In GIS program used for spatial analysis, In case of cutting link in direction of height, the disaster had an impact on South-North axis. Similary, when the link was cut in direction of crosswise, most of transportation disaster influence was generated on east-west axis. This is an essential particular to consider necessarily at traffic aspects of the disaster influence.

Finally, in the result of the average numerical value of mobility decline degree that happened by each link cutting analyzed the highest point, that Yeoksam-1dong, Yeoksam-2dong, Seocho-3dong and Samsung-2dong in Gangnam-gu. Based on this result, when you calculate traffic aspect of the disaster influence in Gangnam-gu, you should consider with above 4 points as the central region.

V. CONCLUSION AND HEREAFER RESEARCH TASK

A. Conclusion

Damage in traffic aspect is very different according to kinds and size of disaster. Accordingly, traffic management is executed too variously. This suggested research for establishing proper disaster influence considering traffic aspect study is progressed.

In analysis result, the case 3, where 3rd link had been cut off, had the worst and widest influence on the area. In case of cutting link in direction of height, the disaster had an impact on South-North axis. Similary, when the link was cut in direction of crosswise, most of transportation disaster influence was generated on east-west axis. The average numerical value of mobility decline was the highest in the order of Yeoksam-1dong, Yeoksam-2Dong, Seocho-3dong and Samsung-2dong in Seoul Metropolitan area.

To minimize damage by disaster, specific and realistic disaster traffic strategy should be arranged in future through this research. Then, we expect that we can reduce social cost caused by disaster.

B. Future research task

How to set range and divide levels, study is analyzed as difference on influence establishment. Therefore, through correct standard or division, coming research should be processed.

This research progressed analysis about disaster effect based on Gangnam-gu. However, there is needed to expand analysis extent such as Seoul city or capital region. According to characteristics of each city or analysis scope, various method of study can be applied. In hereafter, we expect that standard technique may be developed through these researches. If someone conducts disaster influence analysis about transportation, wide disaster management plan will be
established, and also advanced disaster management system will be constructed.

REFERENCES