Assessment of the road network resiliency in the presence of road maintenance sites: An environmental perspective

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Presentation Number: P21-20464

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1- Motivation

- The transportation sector is a major source of air pollution, with Road Maintenance Sites (RMSs) releasing a considerable amount of emissions.
- By causing delays in traffic and increasing fuel consumption, road maintenance activities result in multiple environmental and ecological impacts.
- Evaluation of transportation network performance under incident or disruption/malfunction conditions is of great importance.

2- Background

- The transportation network's performance includes four concepts: reliability, vulnerability, robustness, and resilience.
- These concepts are very close to each other, in such a way that reliability, vulnerability, and robustness are mentioned as resilience characteristics in previous studies.
- Although the concept of resilience has been evolved since the 1950s, many researchers have concluded that there is no unified definition of resiliency.

3- Road Network Resiliency Measures

- Most of the previous studies use topology-based resiliency measures.
- In this study, three resiliency measures are introduced, one of which is traffic-related and the two others are environmental-related:

Travel Time Parameter

$$R_T = \frac{Travel\ time\ (in\ abnormal\ condistion)}{Travel\ time\ (in\ normal\ condition)} \quad (1)$$

Environmental Parameter

$$R_{E1} = \frac{Emitted\ NOx\ (in\ abnormal\ condistion\ )}{Emitted\ NOx\ (in\ normal\ condition)} \quad (2)$$

$$R_{E2} = \frac{Emitted\ CO2\ (in\ abnormal\ condistion)}{Emitted\ CO2\ (in\ normal\ condition)} \quad (3)$$

4- Methodology

- Four distinct methods have been proposed for analyzing the resiliency of transportation networks: 1-Topological 2-Optimization 3-Big Data Analysis and 4-Operational and Simulation models.
- Most previous studies used topological resiliency models; however, it is challenging to evaluate environmental issues with this methodology. Therefore, this study implements a traffic simulation model in order to evaluate the road network resiliency.

5- Traffic simulation

- The Sioux Falls road network is simulated in Aimsun.
- Dynamic User Equilibrium is set as the traffic assignment method.

6- Traffic Simulation Scenarios

- It is assumed that road maintenance sites cause lane closure.
- 8 lane closure scenarios are considered for simulation.
- In each scenario, a specified percentages of links are selected randomly. Then, the rightmost lane in the selected links is set to be closed.
- The selection of links is random, using Aimsun scripting. This selection procedure is only applied to two or more lane links.
- For instance, in the first scenario, the rightmost lane of 10% (percent of disruption= 10) of links is set to be closed. In the second scenario, the rightmost lane of 20% of links is set to be closed. This process is done for 30%, 40%, ..., 80% of links.

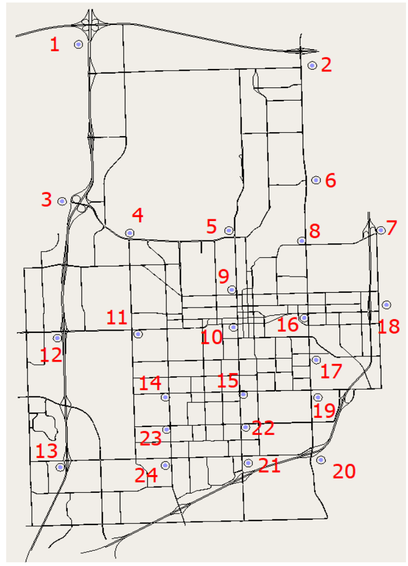

Figure 1: Sioux Falls Network

7- Results

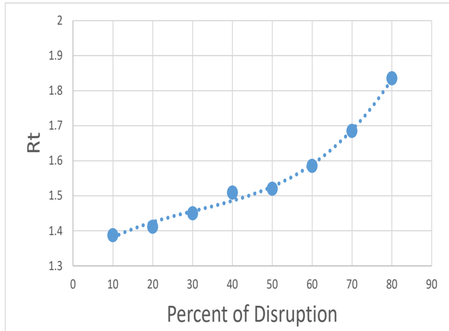

Figure 2: Travel Time Parameter

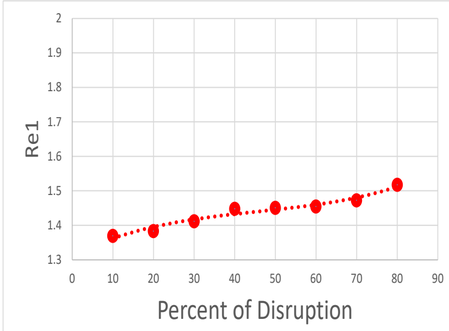

Figure 3: Environmental Parameter (Re1)

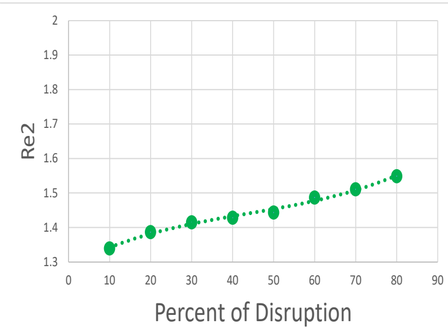

Figure 3: Environmental Parameter (Re2)

8- Conclusion

- Two new road network resiliency parameters are introduced in this study. The values of environmental-related parameters illustrate the importance of considering these parameters in the decision-making process for setting up a road maintenance site.
- In all three parameters, the values increase up to a breakpoint (percent of disruption= 40 %). The values of parameters in percent of disruption= 40 and 50 are almost equal to each other.
- Beyond the breakpoint (percent of disruption = 40% and 50%), the rates of changes are higher than that of before the breakpoint.

9- Future Works

- It is suggested that in future studies, the effect of lane closure in pre-selected sections can be examined.
- In this study, the dynamic user equilibrium is implemented as the traffic assignment method. Different route choice behaviors (e.g., system optimal conditions) should be investigated.