Unhappy relationship between water and road traffic

Effects of rainfall and inundation on road traffic

Toshiyuki Yamamoto, Nagoya University
3 largest metropolitan areas in Japan

- Tokyo
- Osaka
- Nagoya

8.9M Earthquake on 2011/03/11

Toshiyuki Yamamoto, Nagoya University
Outline

• Introduction

• Effect of rainfall on traffic speed: recurrent case

• Effect of inundation by tsunami on road congestion and drownings: non-recurrent case

• On-going research on economic loss by urban flood
น้ำท่วมระดับไหน ไม่ควรถีบลุย

5-10 ซม.
ไม่อันตราย
แต่ควรหาที่สูงๆ

10-20 ซม.
อยู่ใกล้ถนน
ควรเข้าออฟฟิศ

20-40 ซม.
เรียกว่าเสี่ยง
ควรหายใจ

40-60 ซม.
ระดับน้ำสูงสุด

60-80 ซม.
ระดับน้ำสูงสุด

เกิน 80 ซม.
ระดับน้ำสูงสุด

Source: yellowpages.co.th
Car surfing on the road in Japan

Source: https://www.youtube.com/watch?v=lGvyK4Luso
Effects of water on road traffic

Rainfall → Wet road surface → Low visibility
Tsunami → Inundation → Lower speed

Road close
Effect of rainfall on traffic speed

P-DRGS (Probe-based dynamic route guidance system) project

Probe data collection

Calculation of traffic condition

Probe vehicle:
- vehicle with GPS as moving sensor

Traffic information provision

Information provision:
- Personalized multi-mode route guidance
- Real-time traffic management
Traffic speed by weather condition

Probe data collection

Precipitation data

![Probe data collection](image1.png)

![Precipitation data](image2.png)

Traffic speed (km/h)

- no raining 0mm/h
- light rain 0.5mm/h ~ 4.5mm/h
- heavy rain \( \geq 4.5mm/h \)

![Travel speed graph](image3.png)
Travel time ratio compared with no rain condition by road type

<table>
<thead>
<tr>
<th>Rainfall Condition</th>
<th>National Expressway</th>
<th>Urban Expressway</th>
<th>National Road 2</th>
<th>National Road 4</th>
<th>National Road 6</th>
<th>Main Prefectural Road 2 lanes</th>
<th>Main Prefectural Road 4 lanes</th>
<th>Main Prefectural Road 6 lanes</th>
<th>Main City Road 2 lanes</th>
<th>Main City Road 4</th>
<th>Main City Road 6</th>
<th>Other Prefectural Road 2 lanes</th>
<th>Other Prefectural Road 4 lanes</th>
<th>Other Prefectural Road 6 lanes</th>
<th>Other City Road 2 lanes</th>
<th>Other City Road 4</th>
<th>Other City Road 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4.5mm/h</td>
<td>Green</td>
<td>Blue</td>
<td>Green</td>
<td>Blue</td>
<td>Green</td>
<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
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<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>4.5mm/h ≤ Rainfall &lt; 10mm/h</td>
<td>Blue</td>
<td>Green</td>
<td>Blue</td>
<td>Green</td>
<td>Blue</td>
<td>Blue</td>
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<td>Blue</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>≥ 10mm/h</td>
<td>Yellow</td>
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<td>Yellow</td>
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<td>Yellow</td>
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</table>
Economic loss by travel time increase

• 14,139,000 car trips per day in Nagoya metropolitan area
• 24.5 minutes of average travel time per trip
• 9% increase of average travel time by rainfall
• 2400 JPY/hour (20 USD) of value of travel time saving (MLIT, 2009)

1.247 billion JPY (10M USD)?
Effect of inundation by tsunami on road congestion and drownings

Partly supported by Grant-in-Aid for Scientific Research (26220906) from MEXT & JSPS

1. Background

Japan has experienced many earthquakes, typhoons and floods.

Big earthquakes periodically hit Nagoya metropolitan area

- M7.9 in 1605
- M8.6 in 1707
- M8.4 in 1854
- M7.9 in 1944

Next one is anticipated in 30 years with 88% probability
The Great East Japan Earthquake occurred on March 11, 2011. In Tokyo Metropolitan area,

- More than 80% started going home
- 24% drove home
- Over 5 million peoples were unable to get home
2. Objectives

To estimate size of refugees unable to get home, traffic congestion and drownings at the next big earthquake hitting Nagoya

Key points:
- Excess car demand returning home
- Conflict between going home and evacuation from anticipated Tsunami
9. Traffic simulation of going home trips

- Assumed earthquake: Occurred at noon in weekday
- Timing of trip: Start going home immediately after the quake
  Evacuation from Tsunami at 5 min. after the quake
- Degraded road network: One lane closure for multiple lane roads
  Decreased capacity for one lane roads
  Unable to use expressways

- Traffic flow

  Capacity constraint is considered for inflow

  [Diagram showing traffic flow with nodes, in-flow, next link, FIFO principle, speed determined by density, waiting queue if capacity constraint]
10. Results of simulation

5 min. after

30 min. after

60 min. after

Persons in queue

Tsunami
10. Results of simulation

- **Base case**
  - Stochastic route choice under current situation
  - No information access

- **Information access case (current situation and family safety)**
  - Reduced trips by information access

<table>
<thead>
<tr>
<th></th>
<th>Base case</th>
<th>Info. access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returned home in 4 hrs.</td>
<td>2,371,000</td>
<td>2,230,000</td>
</tr>
<tr>
<td></td>
<td>(74%)</td>
<td>(78%)</td>
</tr>
<tr>
<td>Unable to evacuate before flooded</td>
<td>438,000</td>
<td>382,000</td>
</tr>
</tbody>
</table>
On-going research on economic loss by urban flood

“Advancing co-design of integrated strategies with adaptation to climate change in Thailand (ADAP-T)” supported by JICA/JST

Principle Investigator: Prof. Taikan Oki, University of Tokyo
“Advancing co-design of integrated strategies with adaptation to climate change in Thailand (ADAP-T)” supported by JICA/JST

Topic: Urban Flood caused by Heavy Rainfall in Bangkok
by Prof. Shinichiro Nakamura, Nagoya University

How much is economic loss due to urban flood in Bangkok?
Research flow

a) Database
- Historical precipitation, precipitation under CC

b) Model Development
- Forecast rainfall under CC
- Flood and drainage system model
- Transportation network model
- Transportation Network
- Urban Facilities
- b) Model Development

G1

G2

Overall goal in 5 years

Historical precipitation, precipitation under CC

Drainage map, historical flood

Transportation network, person trip, value of time

Transportation network model

Transportation Network
Urban Facilities

G1

G2

d) Urban flood risk related traffic

c) Urban flood map under CC

e) Evaluate adaptation measures

f) Appropriate adaptation approaches for BKK

Overall goal in 5 years

Historical precipitation, precipitation under CC

Drainage map, historical flood

Transportation network, person trip, value of time

Transportation network model

Transportation Network
Urban Facilities

G1

G2