The Preliminary Study on Evaluation of Taiwan Freeway No.1 Using Maintenance Condition Index

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Introduction
Background

Regular Inspection

- **Pavement Survey**
  - Manual visual inspection of pavement surface distress

- **Pavement Inspection**
  - Use indicators to assess the pavement condition

Factors:

- Manpower, time, and cost
- Inspector’s safety concerns
- Inspector’s experience and training
Research Purposes

1. **Maintenance Control Index, MCI**

   - Calculate the cracking rates, rut depth and roughness
   - Assess the flexible pavement to reach the maintenance standard indicators.
   - Evaluate the worst case lane for heavy truck (south bound, third lane)

MCI evaluates pavement conditions of National Freeway south bound 374.3 km

MCI used for freeway feasibility

pavement condition and distresses

Maintenance conditions in different section

MCI evaluates pavement condition on different section
Literature Review
Pavement Maintenance Management Concept

- Long-term maintenance of the pavement in a good condition saved maintenance costs about 4 to 5 times compared to the pavement under severe conditions.
- Administration shall forecast and evaluate the deteriorations and distresses.

(Japan Road Association, 2006) (State of North Carolina, 2016)
Flexible Pavement Distress Factors and Types

Distress Factor
1. Traffic
2. pavement material
3. Environment
   (temperature, humidity)

Type of Distress
1. Surface distress
   (cracks, potholes)
2. Bottom distress (rutting)
3. Comfort level (roughness)

Pavement Performance Evaluation Method

**Pavement Condition Index, PCI**

- Common used pavement condition assessment indicator
- 19 types of flexible pavement distresses

**Common pavement indicators in recent years**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Cracking</th>
<th>Rutting</th>
<th>Flatness</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Maintenance Control Index)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP-21</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Moving Ahead for Progress in the 21st Century Act)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Present Serviceability Index)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Method
MCI Calculation Formula

(Maintenance Control Index, MCI)

Cracking rate (C, %)
Rutting (D, mm)
Roughness (σ, mm)

Calculate the existing data into the following formula

\[
\begin{align*}
MCI &= 10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2} \\
MCI_0 &= 10 - 1.51C^{0.3} - 0.30D^{0.7} \\
MCI_1 &= 10 - 2.23C^{0.3} \\
MCI_2 &= 10 - 0.54D^{0.7}
\end{align*}
\]

(Japan pavement maintenance and rehabilitation manual, 2013)
### MCI Parameter Calculation - Cracking Rate

#### Cracking rate calculation reduction rate

- **0.5 m**

<table>
<thead>
<tr>
<th>Type of distress</th>
<th>Quantity or proportion Inside the grid</th>
<th>Calculated area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack (strip)</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>≥2</td>
<td>100</td>
</tr>
<tr>
<td>Repaired area (%)</td>
<td>0~25</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>25~75</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>≥75</td>
<td>100</td>
</tr>
</tbody>
</table>
Prior Investigation

National Freeway No. 1 south bound single lane (total 374.3 km)

Heavy vehicle driving lane (third lane)

<table>
<thead>
<tr>
<th>Bureau</th>
<th>Section Jurisdiction</th>
<th>Total Mileage (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starting point</td>
<td>End point</td>
</tr>
<tr>
<td>North</td>
<td>0K+000</td>
<td>100K+800</td>
</tr>
<tr>
<td>Middle</td>
<td>100K+800</td>
<td>251K+100</td>
</tr>
<tr>
<td>South</td>
<td>251K+100</td>
<td>374K+320</td>
</tr>
</tbody>
</table>

Starting Point: Expansion Joint

End point: expansion joint

Pavement analysis range
Pavement Condition Survey Vehicle

- Camera
- Linear laser scanner
- Accelerometer
- Laser
- Camera
- Laser speedometer
- Direction
Analysis and Results
National Freeway No. 1 Overall Pavement Condition

Japan Capital Expressway Maintenance

Target $MCI_0 > 5.6$

- Mean: 7.73
- S.dev: 0.884
- N: 3

95% Confidence Level
$MCI = 6.1$
National Freeway No. 1 Overall Pavement Condition

- 99% section cracking rate are less than 10%
- Standard deviation flatness averages 1.50 mm
- The highest parameter of MCI and MCI deduction is rutting
Traffic Volume Source

(Traffic Data Collection System, TDCS)

ETC (Electronic Toll Collection)

- **TimeInterval**: Report production time
  (statistics every 5 minutes)
- **GantryID**: Station number
- **Direction**: Car direction
- **VehicleType**: Vehicle traffic volume

Diagram:
- Midpoint
- Gate 1
- Gate 2
- Gate 3
- Midpoint
- Gantry (2) traffic
- ETC gate
## Equivalent Standard Axle Load Conversion

### National Freeway Standard Axle Correction Table

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Car</th>
<th>Truck</th>
<th>Van</th>
<th>Heavy truck</th>
<th>Trailer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of axes</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>ESAL Conversion factor</td>
<td>0.0004</td>
<td>0.0035</td>
<td>0.51</td>
<td>0.51</td>
<td>5.28</td>
</tr>
</tbody>
</table>

**Calculate the number of five types of vehicles from ETC data**

Multiply the number of vehicles by the ESAL conversion factor and add up the total.

18 kip equivalent standard axle load (ESALs)
Traffic Volume Corresponding to Each Mileage

Mileage (m)

Traffic Volume

North Bureau
Mid Bureau
South Bureau

Hsinchu area
Changhua area

AASHTO Traffic classification
99.4% Heavy traffic
0.6% Medium traffic

000K+000 050K+000 100K+000 150K+000 200K+000 250K+000 300K+000 350K+000

Traffic (10^5 ESALs)
The results of the hierarchical cluster analysis show that it is ideal to divide the traffic volume into three clusters.
Traffic Volume Cluster Ratio of Each Bureau

North Bureau: 91.2%
Mid Bureau: 61.2%
South Bureau: 37.6%
Engineering Bureau: 59.7%

Light: 8.8%
Mid: 38.8%
Heavy: 2.7%
Traffic Volume Analysis of Each Bureau

- Different bureau has significant difference in traffic volume.
- The traffic volume of the south bureau is higher than the North bureau and Mid bureau.

Median verification for traffic volume of each bureau

Total median = 9,076,619.36
# MCI₀ Data distribution Condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>North bureau</th>
<th>Mid bureau</th>
<th>South bureau</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>6.0</td>
<td>6.4</td>
<td>5.7</td>
</tr>
</tbody>
</table>

**Distribution of National Freeway No. 1 MCI Data**
Analysis of the Pavement Condition on Each Bureau

- Different bureau significant difference in different MCI.
- South bureau MCI score is lower than North bureau and Mid bureau.

Median verification of MCI for each maintenance section

PE 2019
Different bureau has different traffic volume and pavement conditions.

Setting different curing threshold according to different bureau’s condition
Conclusion and Suggestion
Conclusions

National Freeway No. 1

1. More than 95% of road sections have reached the Japanese maintenance target.
2. The most serious distress is rutting.

Each Bureau

1. Traffic volumes different in each bureau.
2. Different Bureau have different MCI score.
3. The pavement maintenance threshold should be design according to the conditions of the area.
Suggestions

**Data Accumulation**
It is recommended to collect multi-year pavement condition inspection data and maintenance data for the pavement distress prediction in the future.

**Traffic**
It is recommended to collect the traffic volume data of each lanes to study the correlation between traffic volume and MCI.

**Maintenance Goal**
Pavement distress, maintenance plans and traffic volume data of different area or different grades need to collect in order to design a pavement maintenance target.
Thank you