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

By

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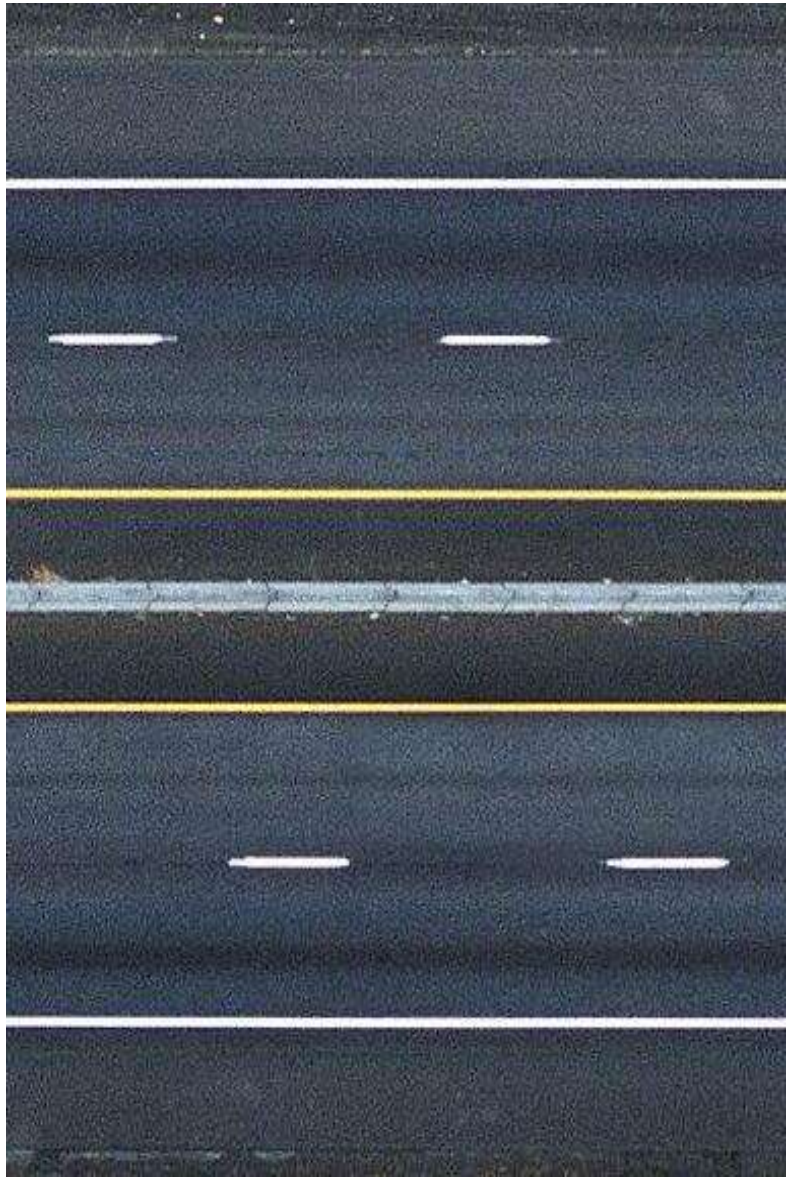

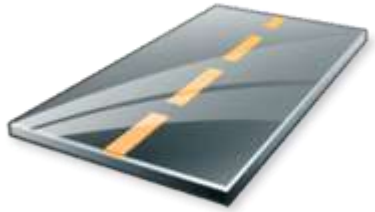

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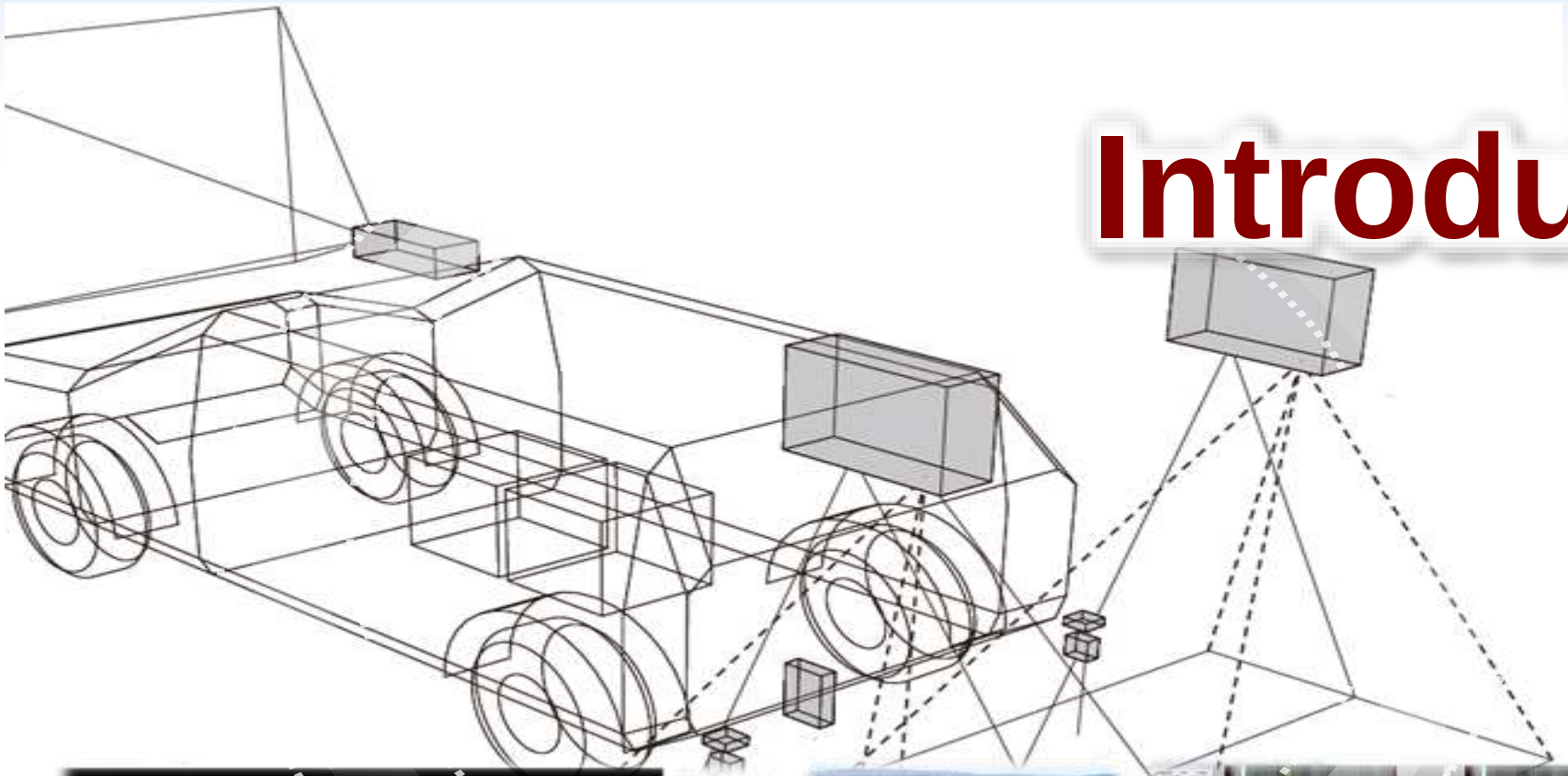
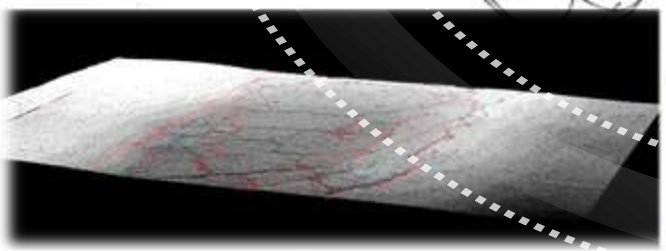
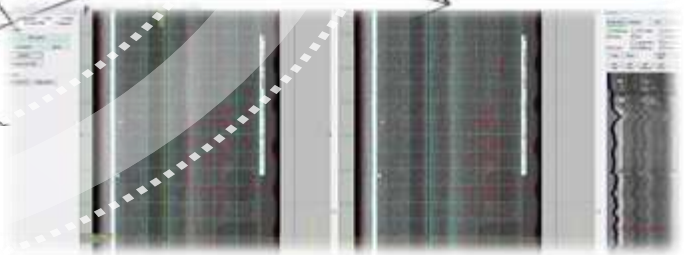
Introduction







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Background

Regular Inspection

➢ Pavement Survey

Manual visual inspection of pavement surface distress

- Manpower, time, and cost
- Inspector's safety concerns
- Inspector's experience and training

➢ Pavement Inspection

Use indicators to assess the pavement condition

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

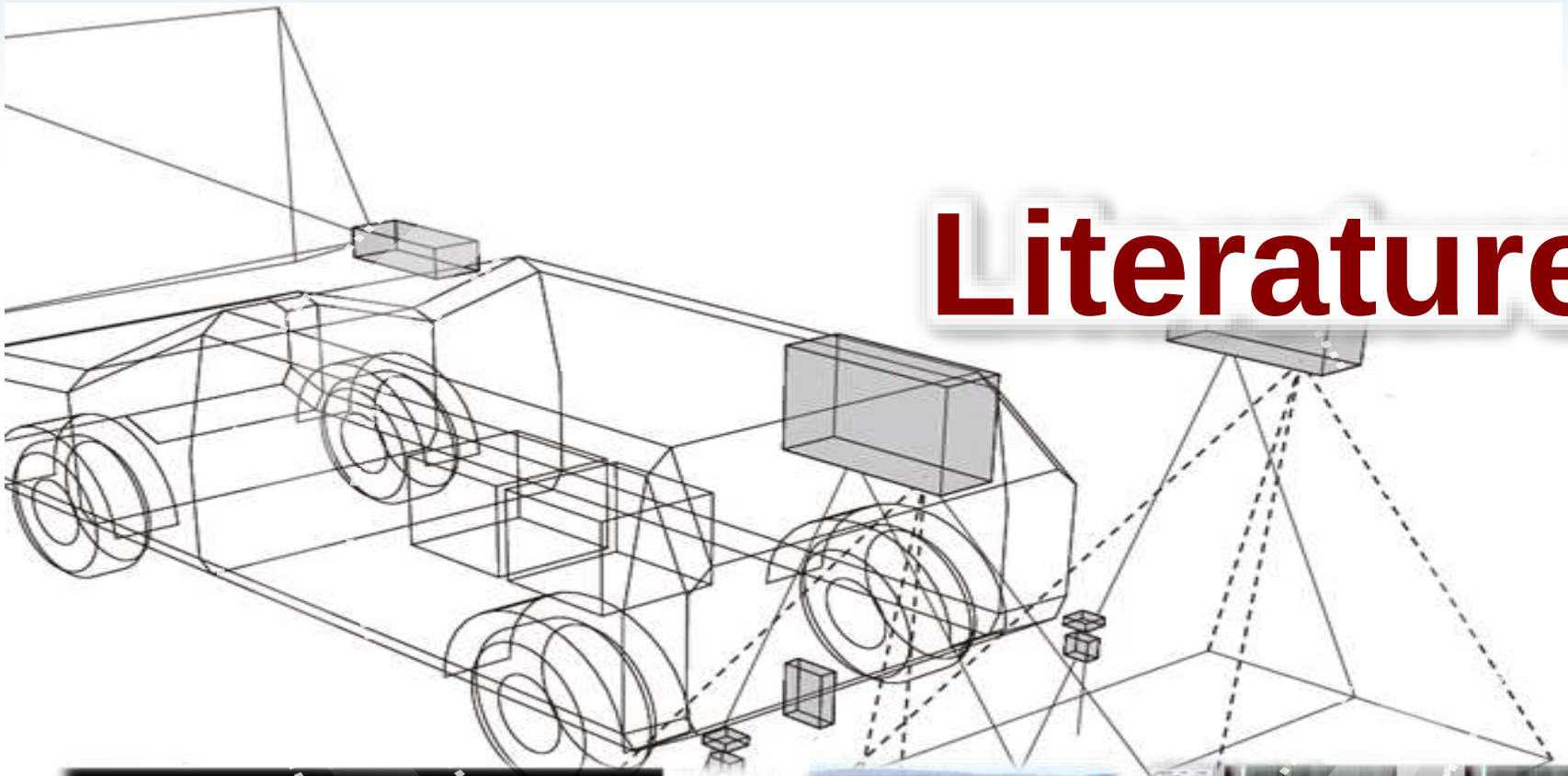
MCI used for freeway feasibility

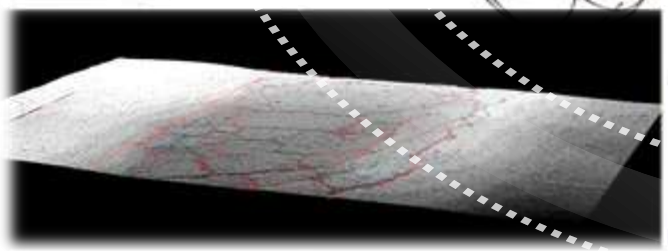
pavement condition and distresses

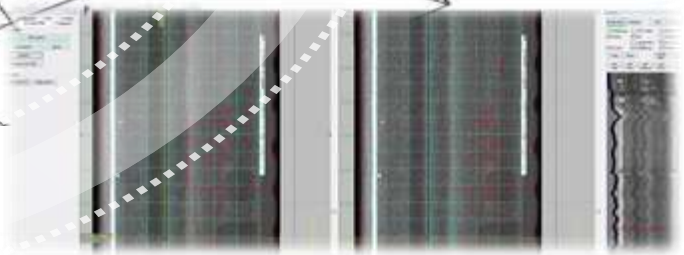
Maintenance conditions in different section

MCI evaluates pavement condition on different section

Literature Review







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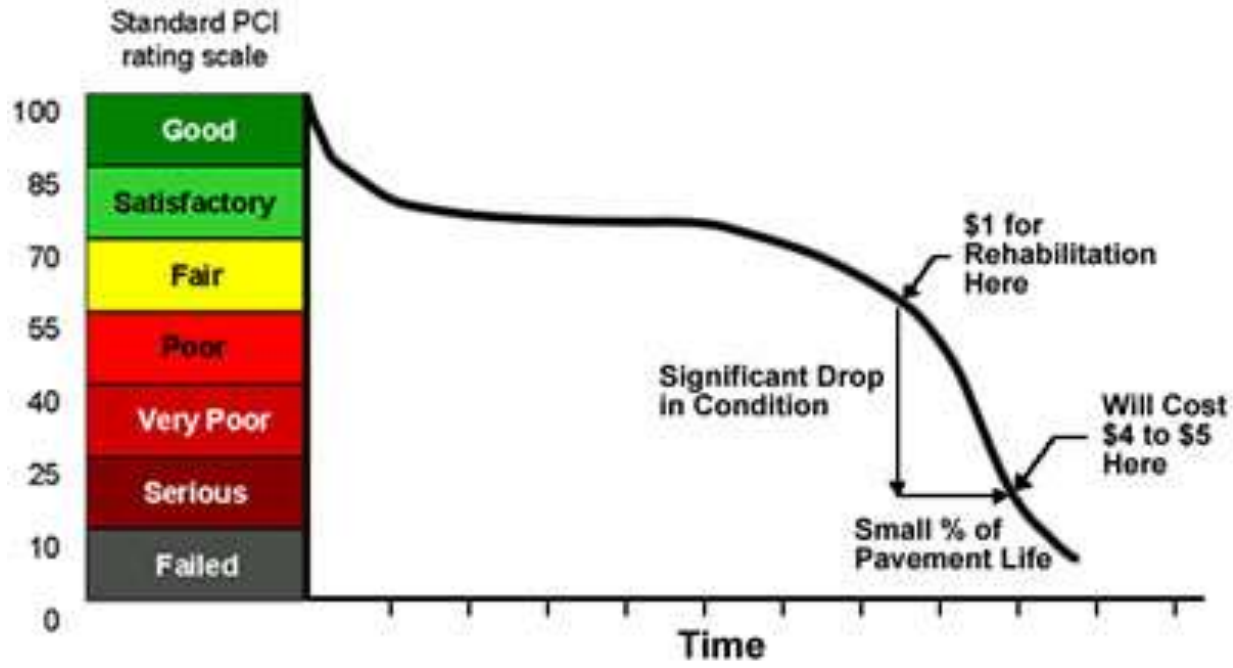
Pavement Maintenance Management Concept

- 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)

(Guo, Jun-Hong, 2017)(Liao, Xiao-Yuan, 2009) (Behiry, 2012) (Huang, 2004)

Pavement Performance Evaluation Method

Pavement Condition Index, PCI

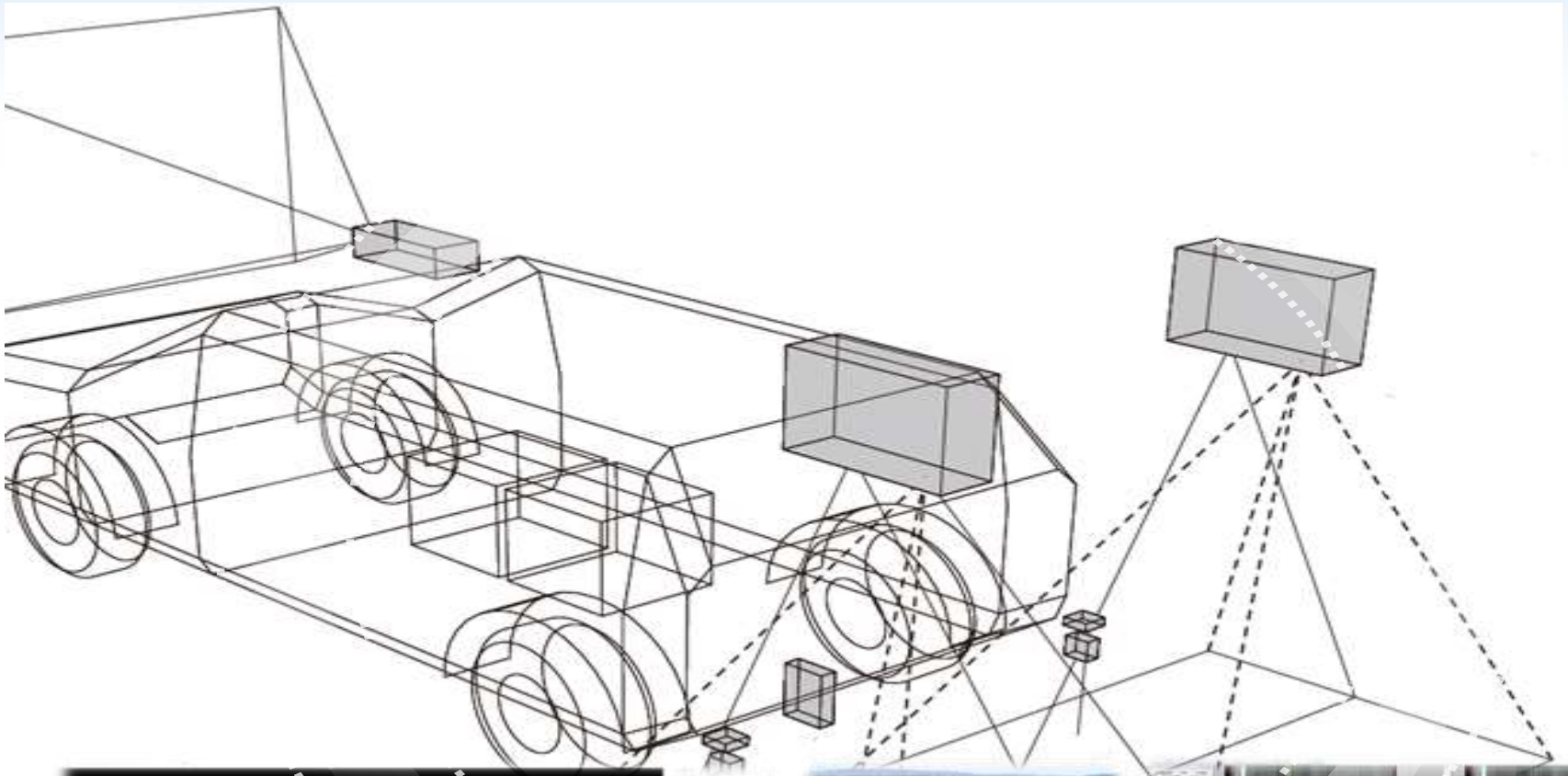
- Common used pavement condition assessment indicator
- 19 types of flexible pavement distresses

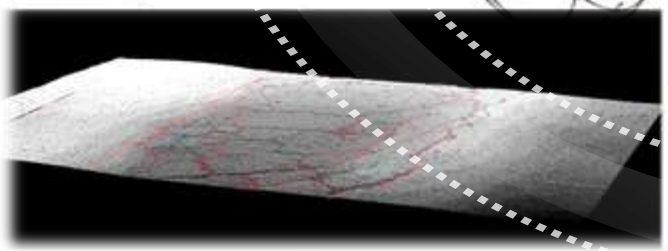
Common pavement indicators in recent years

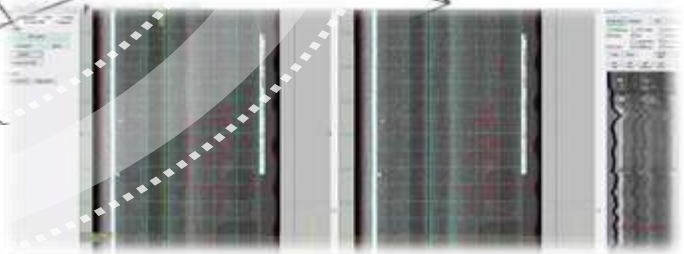
Indicator	Cracking	Rutting	Flatness
MCI (Maintenance Control Index)	✓	✓	✓
MAP-21 (Moving Ahead for Progress in the 21st Century Act)	✓	✓	✓
PSI (Present Serviceability Index)	✓	✓	✓

(Japan Road Association, 2019)(ASTM D6433, 2016)(AASHTO, 1993)(FHWA-HIF-17-022 ,2016)

Method







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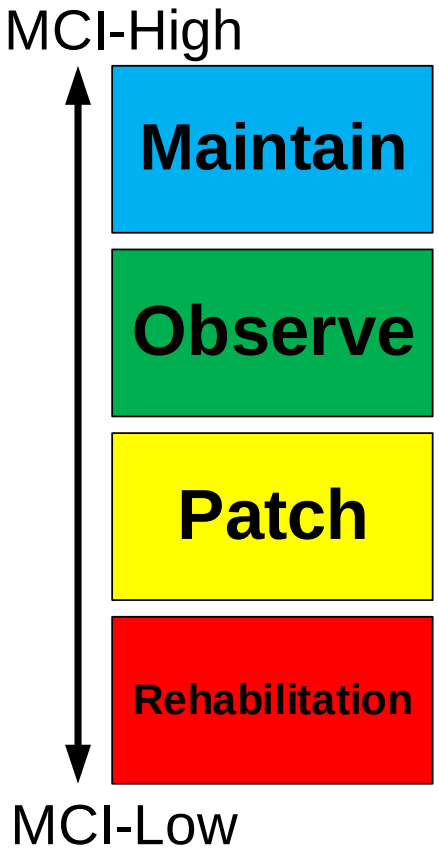
MCI Calculation Formula

(Maintenance Control Index, MCI)



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

Japan Expressway
Calculation parameter

Calculate the existing data into the following formula

$$MCI = 10 - 1.48C^{0.3} - 0.29D^{0.7} - 0.47\sigma^{0.2}$$

$$MCI_0 = 10 - 1.51C^{0.3} - 0.30D^{0.7}$$

$$MCI_1 = 10 - 2.23C^{0.3}$$

$$MCI_2 = 10 - 0.54D^{0.7}$$

MCI、MCI_0 Formula difference → Roughness

(Japan pavement maintenance and rehabilitation manual, 2013)

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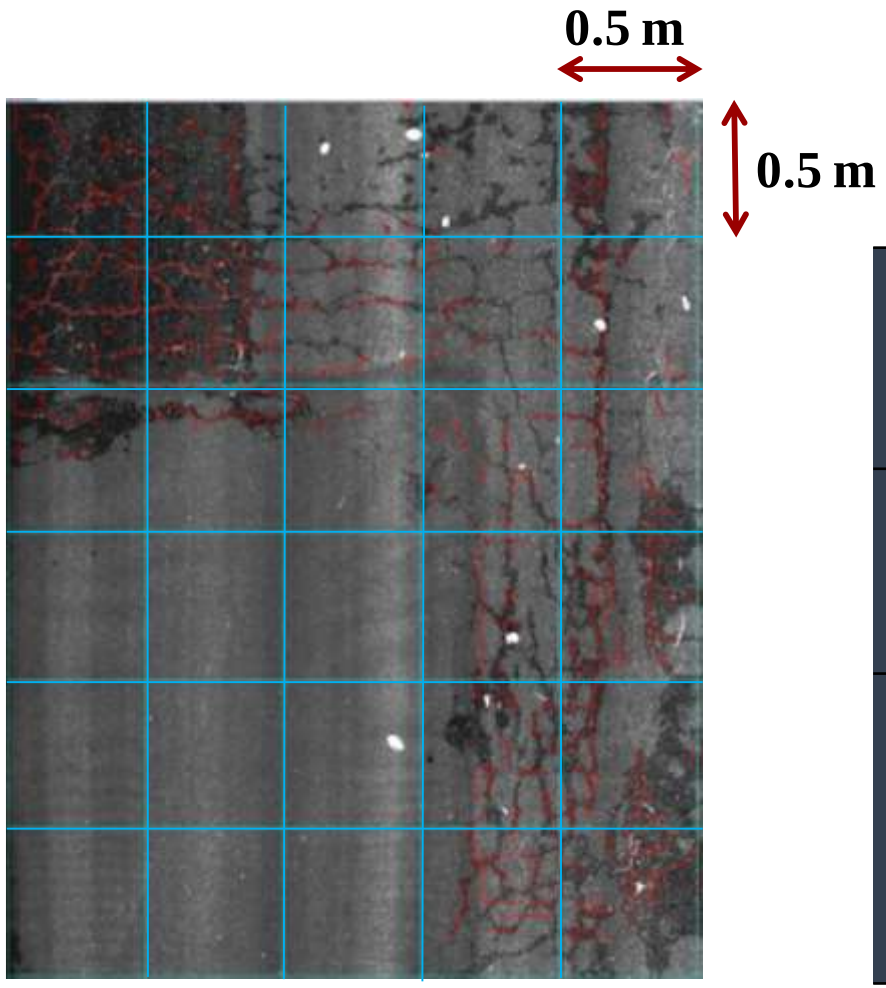
MCI Parameter Calculation - Cracking Rate



Cracking rate calculation reduction rate

Type of distress	Quantity or proportion Inside the grid	Calculated area (%)
Crack (strip)	1	60
	≥2	100
Repaired area (%)	0~25	0
	25~75	50
	≥75	100

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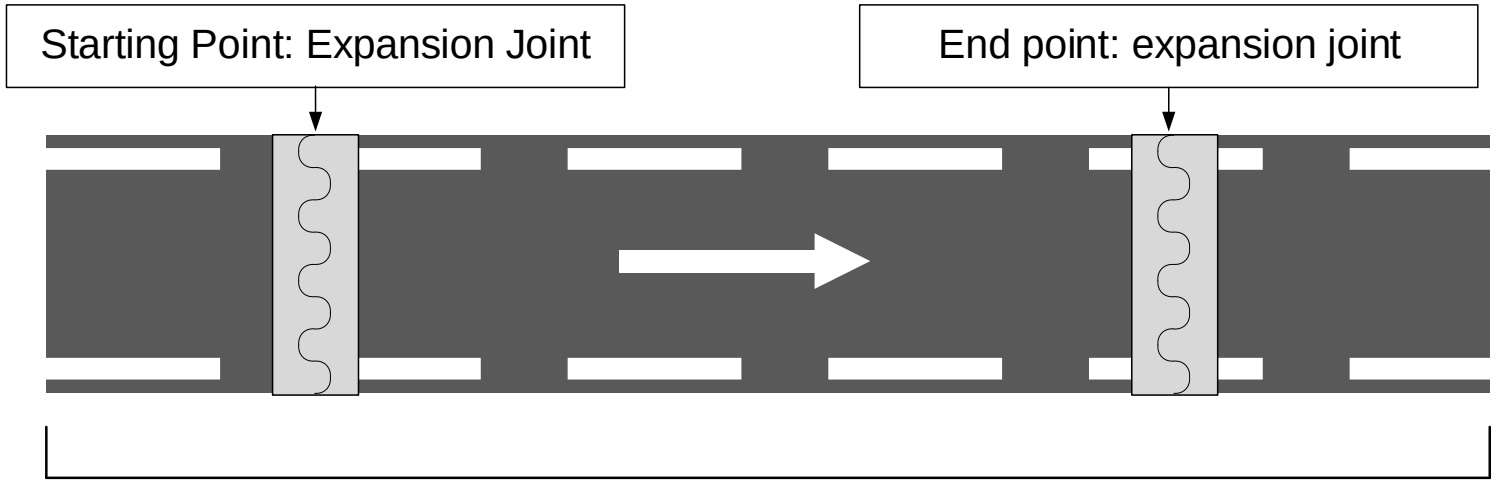
Prior Investigation

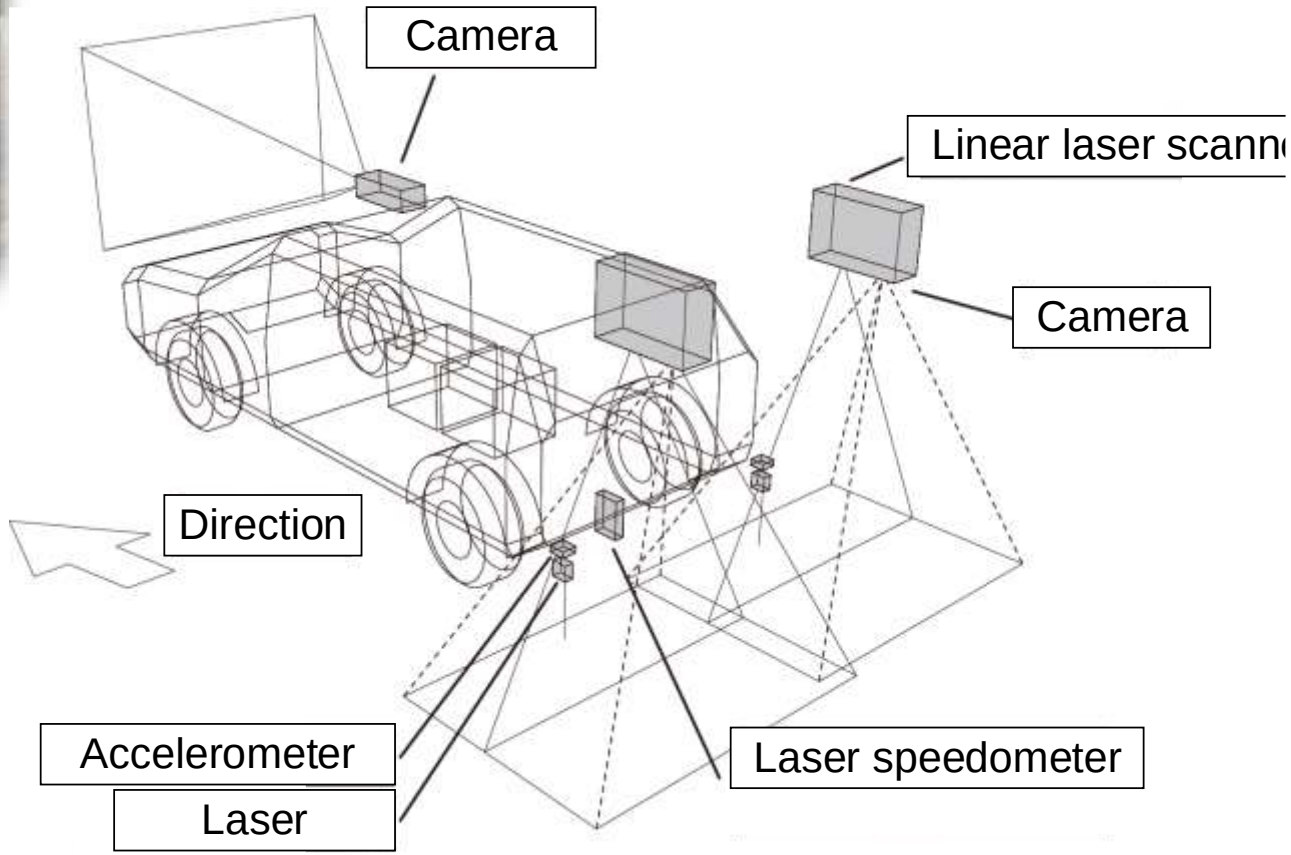
National Freeway No. 1 south bound single lane (total 374.3 km)

◆ **Heavy vehicle driving lane (third lane)**

Bureau	Section Jurisdiction		Total Mileage (km)
	Starting point	End point	
North	0K+000	100K+800	100.8
Middle	100K+800	251K+100	150.3
South	251K+100	374K+320	123.2



Pavement Condition Survey Vehicle



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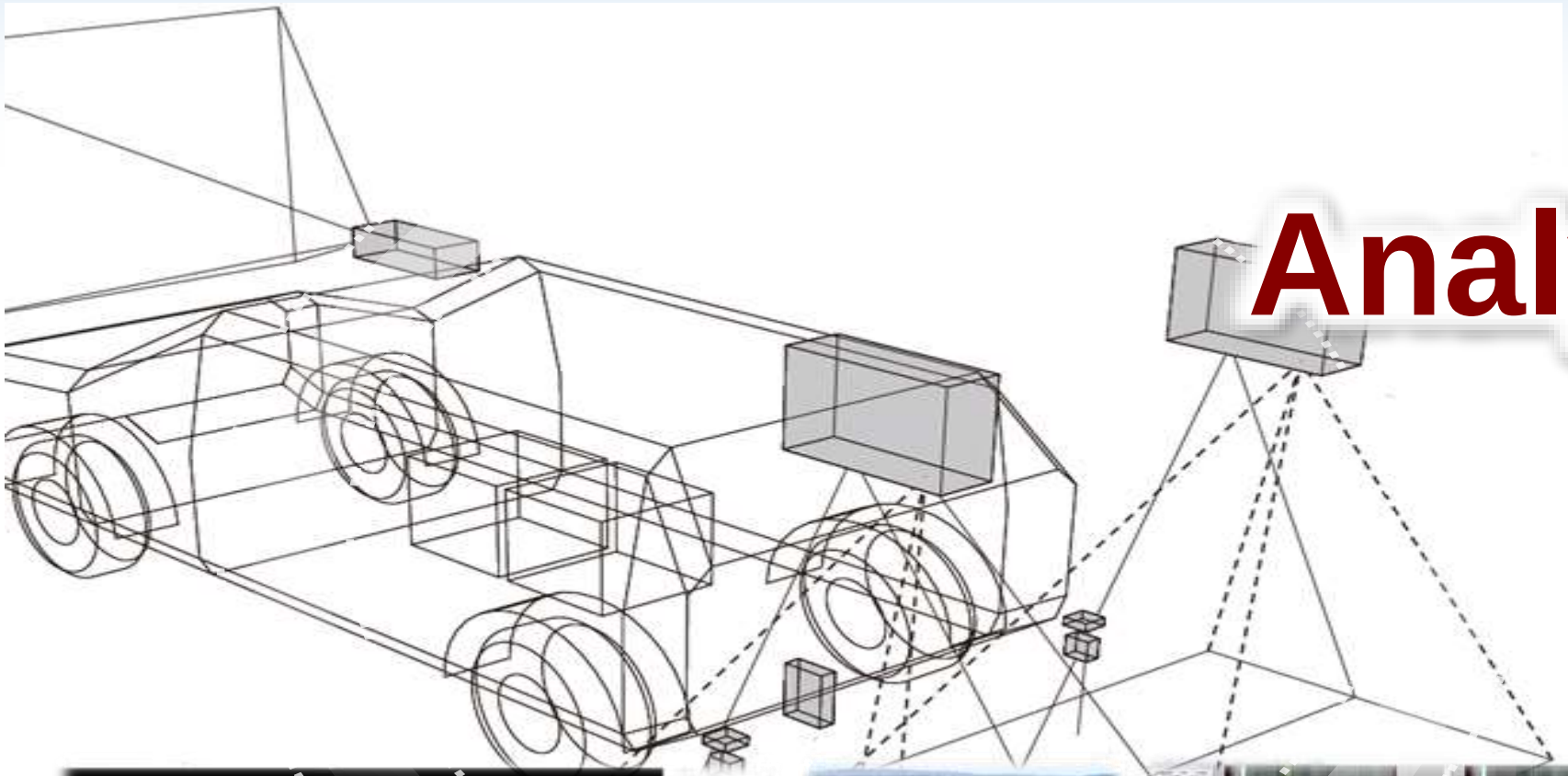
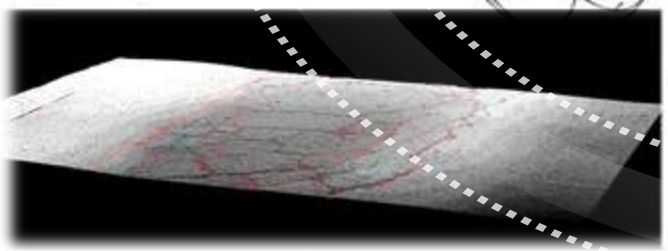
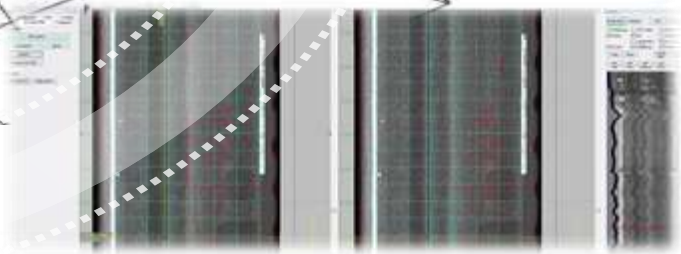
Analysis and Results







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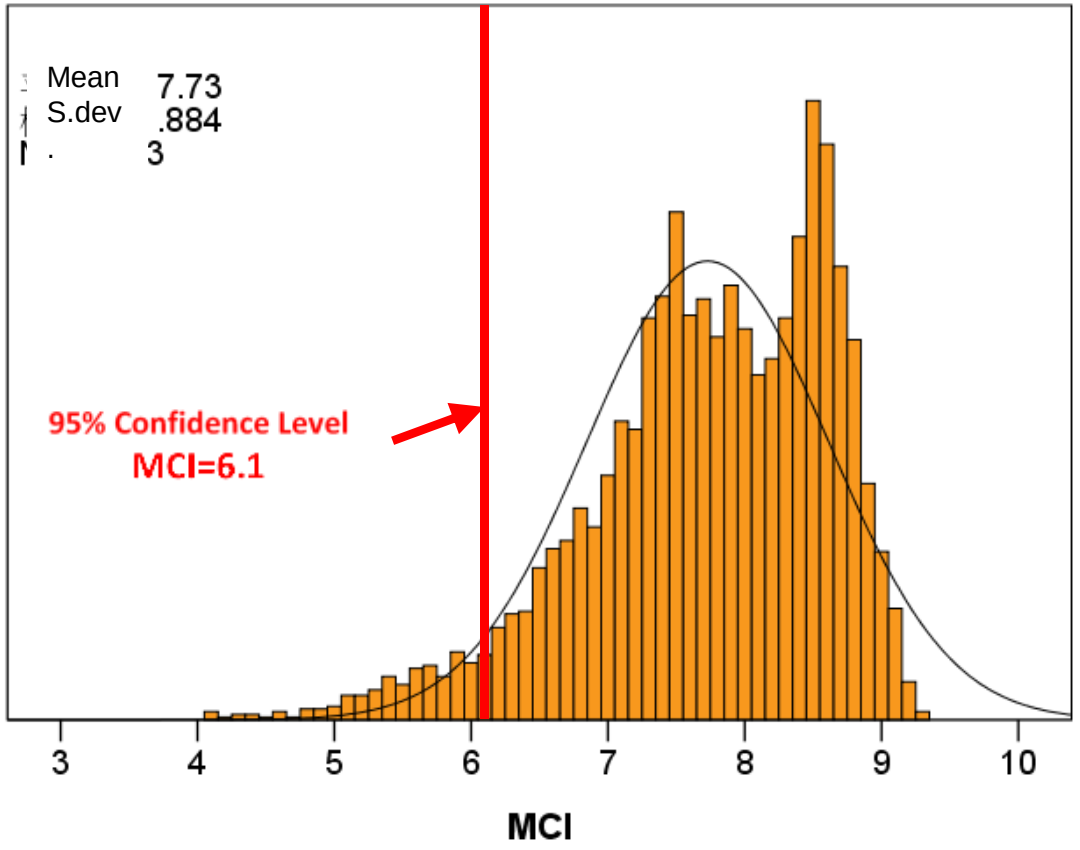
National Freeway No. 1 Overall Pavement Condition

Japan Capital Expressway Maintenance

Target MCI_0>5.6



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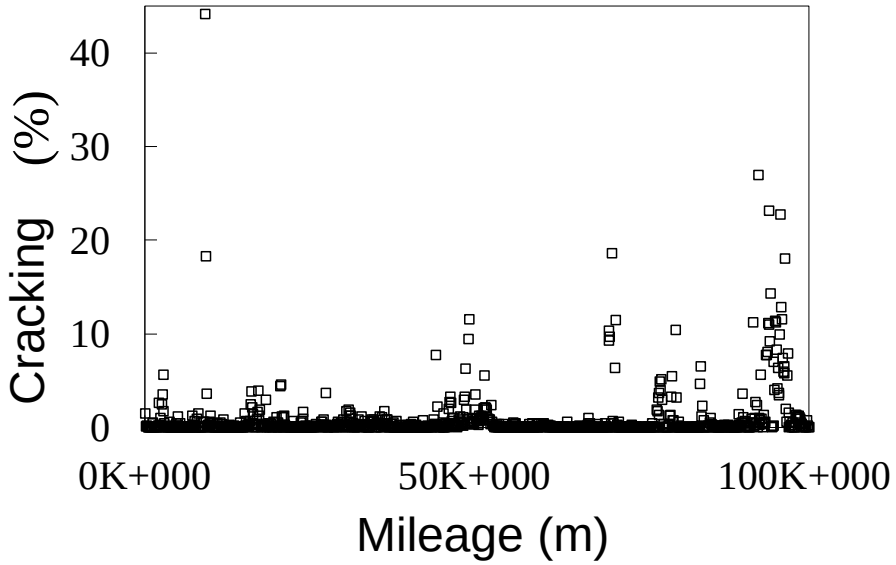
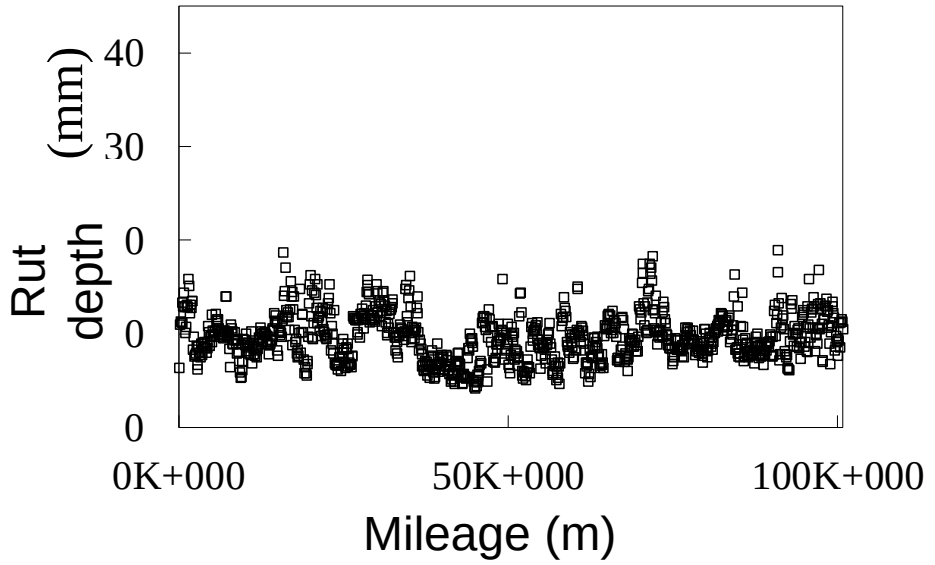
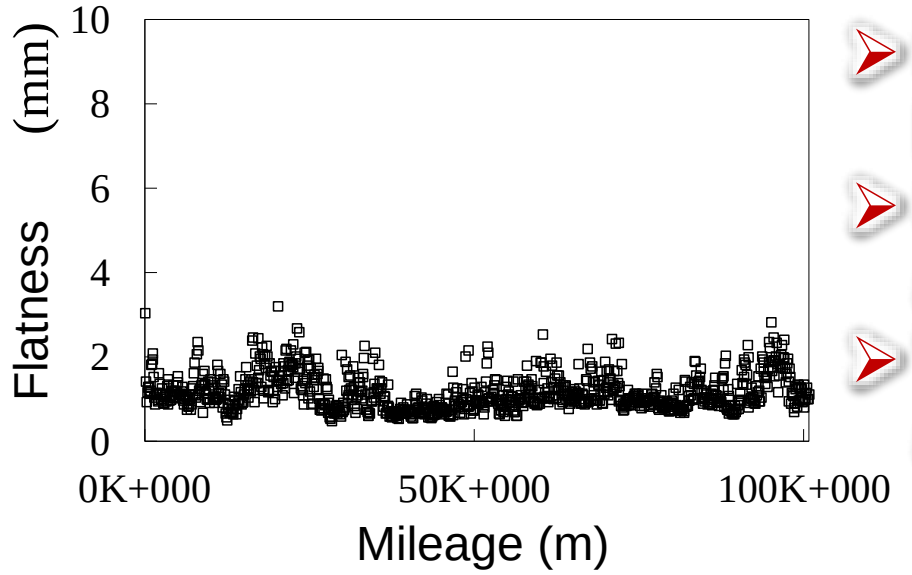
National Freeway No. 1 Overall Pavement Condition







- **99% section cracking rate are less than 10%**
- **Standard deviation flatness averages 1.50 mm**
- **The highest parameter of MCI 0 and MCI deduction is rutting**

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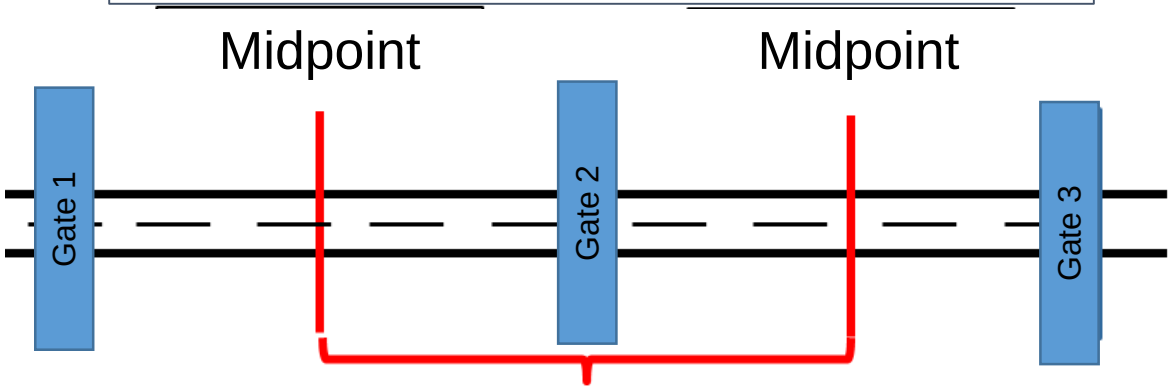
Traffic Volume Source

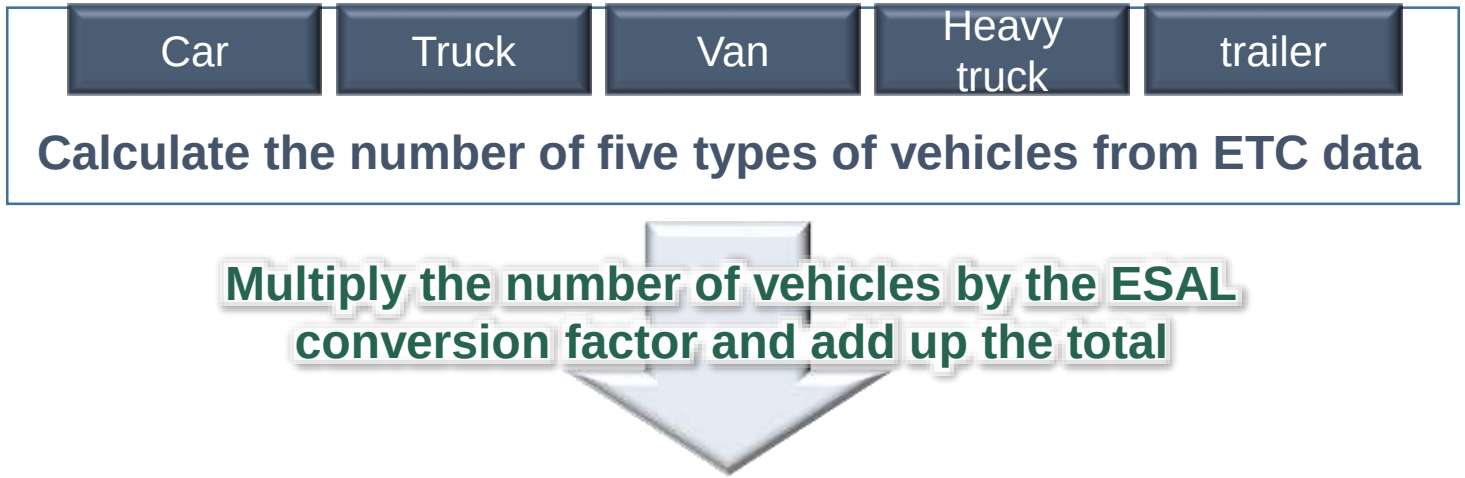
(Traffic Data Collection System, TDCS)

ETC (Electronic Toll Collection)

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



Equivalent Standard Axle Load Conversion

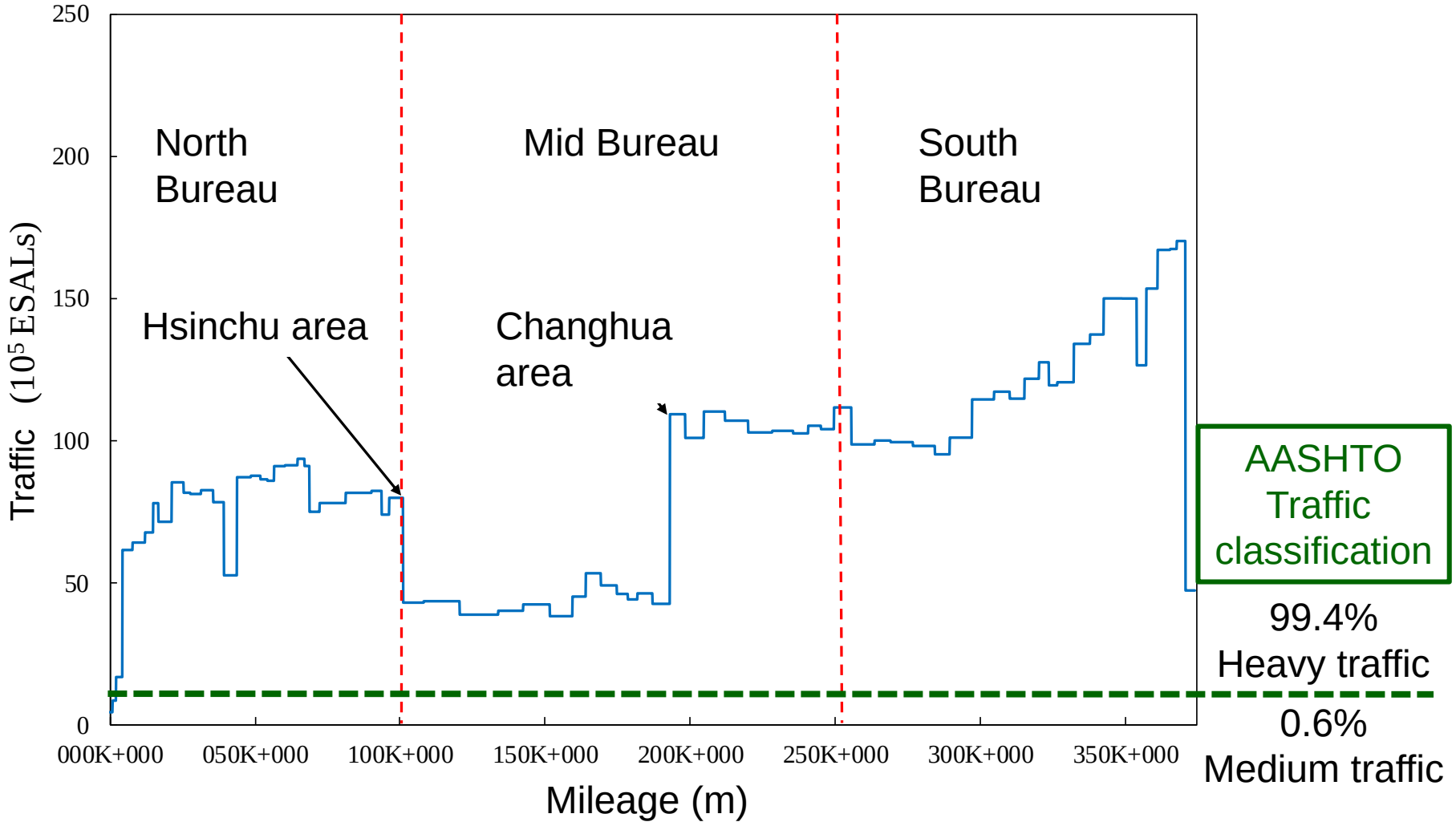


National freeway standard axle correction table

	Vehicle Type				
	Car	Truck	Van	Heavy truck	Trailer
Number of axes	2	2	2	2	4
ESAL Conversion factor	0.0004	0.0035	0.51	0.51	5.28

Yiheng Engineering Technology Consulting Co., Ltd., (2016)

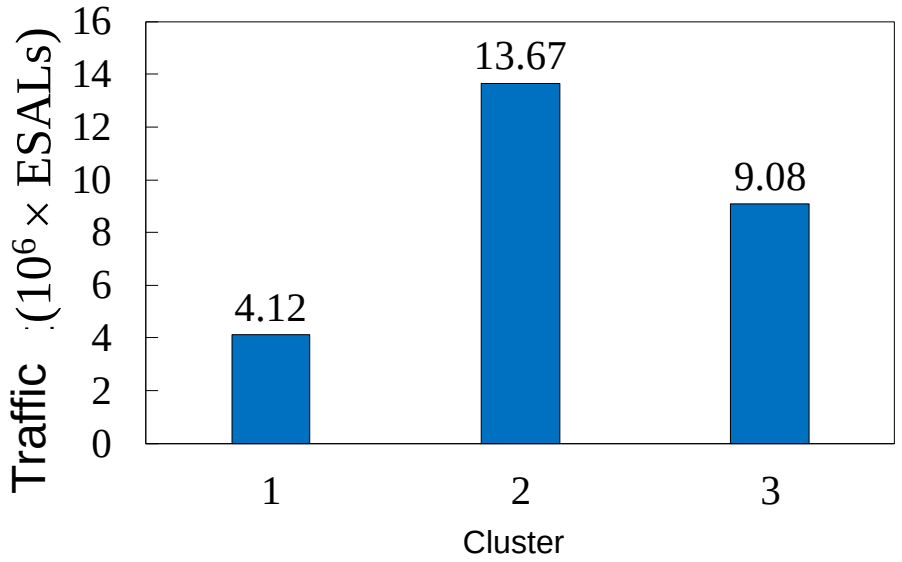
Traffic Volume Corresponding to Each Mileage



Traffic Volume Classification

The results of the hierarchical cluster analysis show that it is ideal to divide the traffic volume into three clusters.

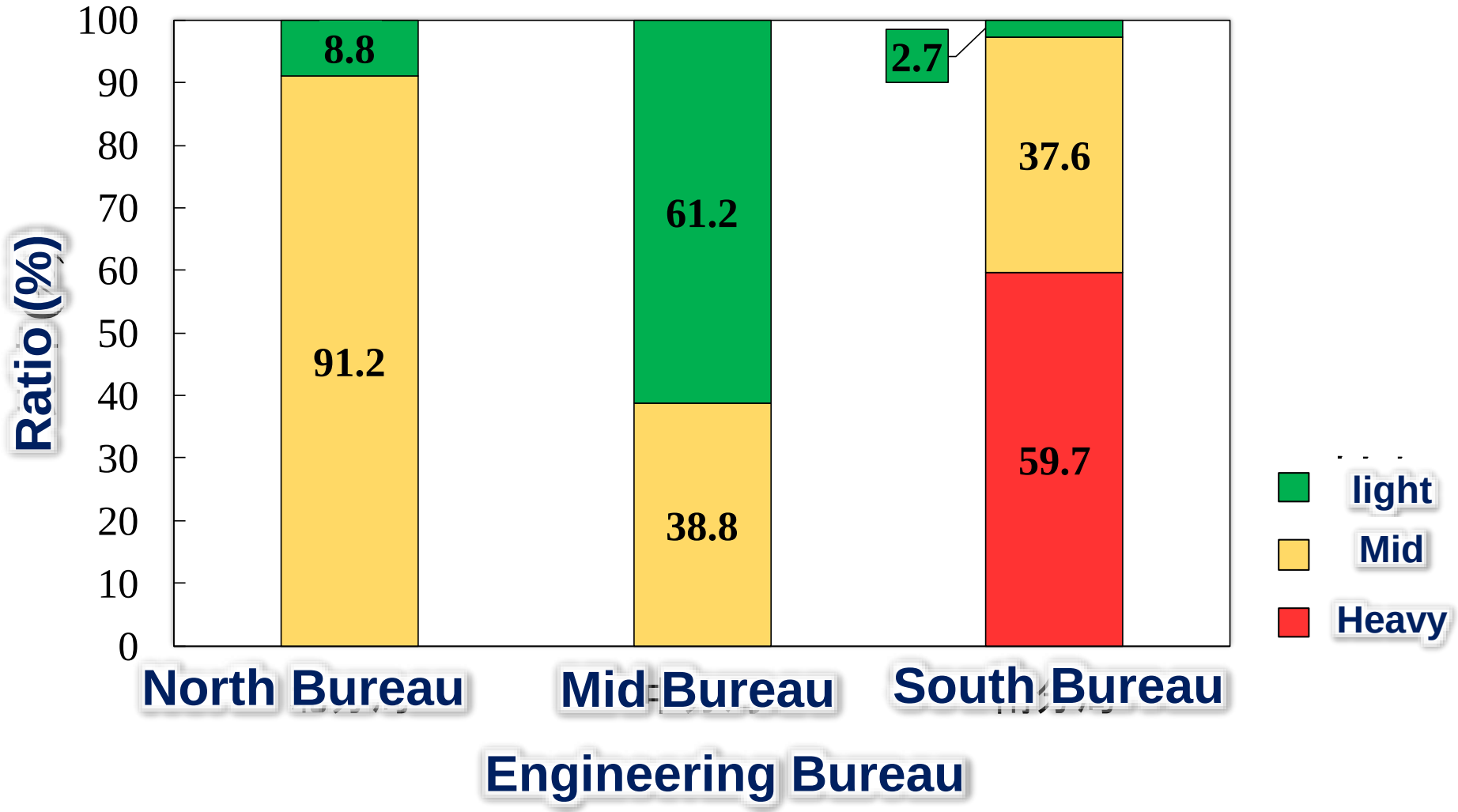
K-means cluster analysis



Cluster	Group name
1	Light
2	Middle
3	Heavy

	Cluster		Error		F	Sig.
	Av. sum of square	Deg. of freedo	Av. sum of square	Deg. of freedom		
TrafficVolume	4.1×10^{14}	2	2.2×10^{12}	71	186.092	.000

Traffic Volume Cluster Ratio of Each Bureau



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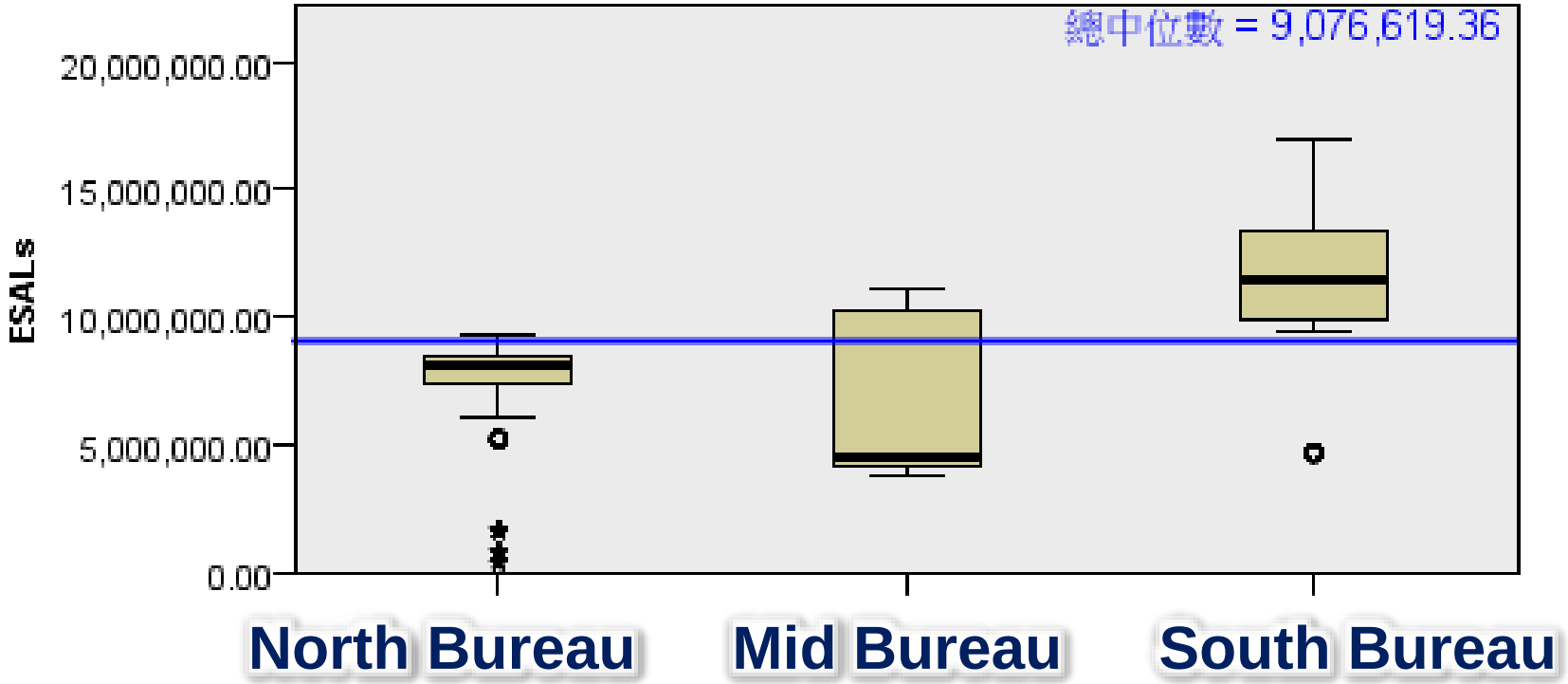
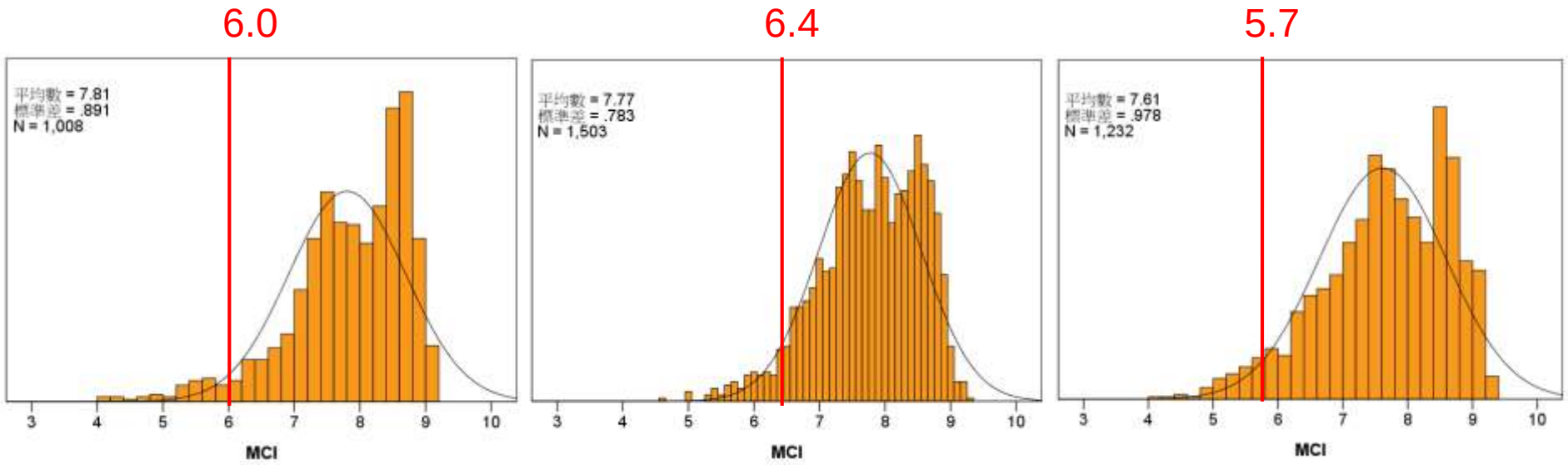
Traffic Volume Analysis of Each Bureau



Median verification for traffic volume 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.

MCI_0 Data distribution Condition



Distribution of National Freeway No. 1 MCI Data

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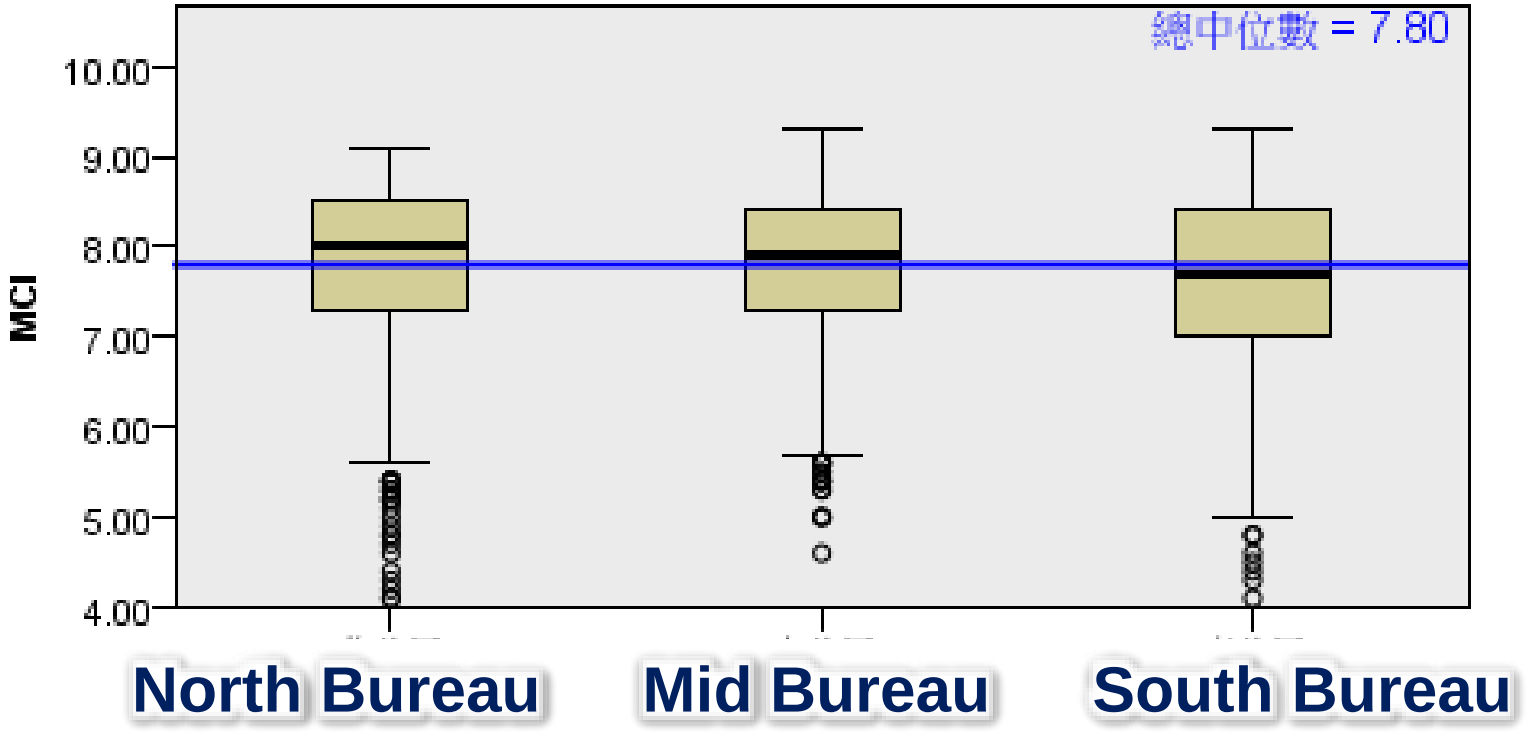
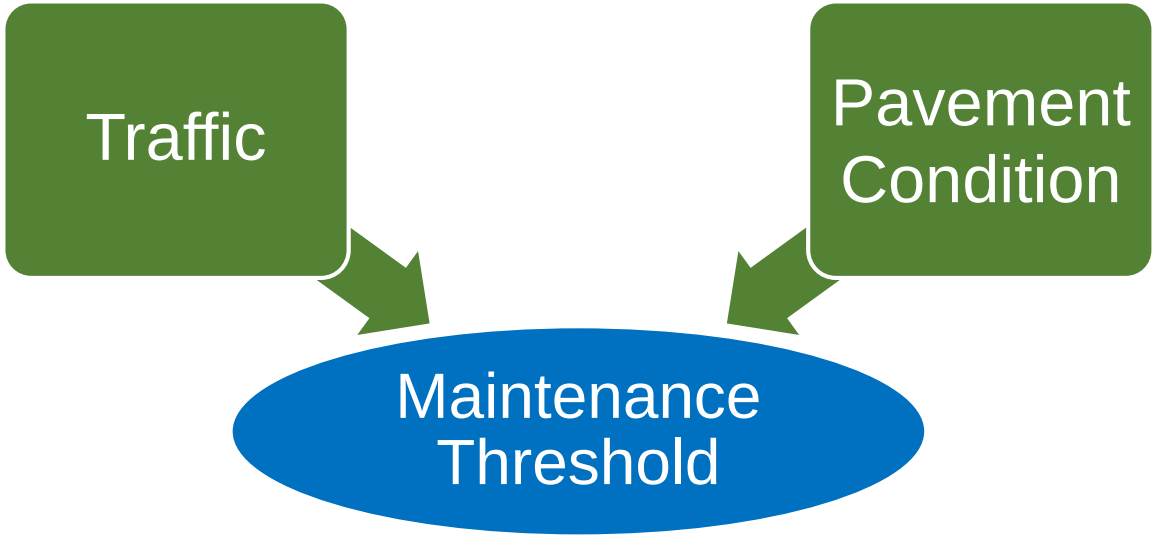
Analysis of the Pavement Condition on Each Bureau



Median verification of MCI for each maintenance section

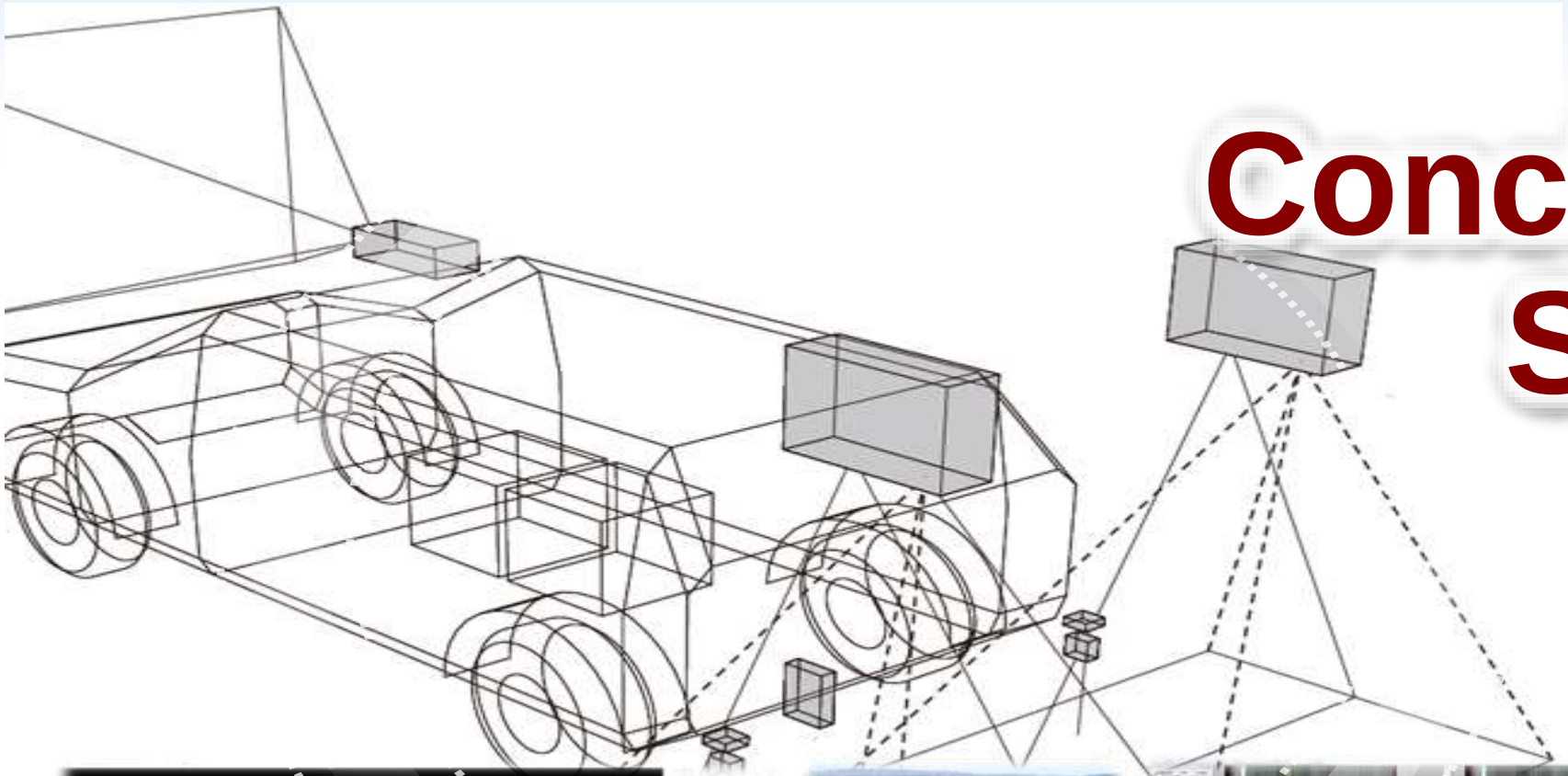
- Different bureau significant difference in different MCI.
- South bureau MCI score is lower than North bureau and Mid bureau.

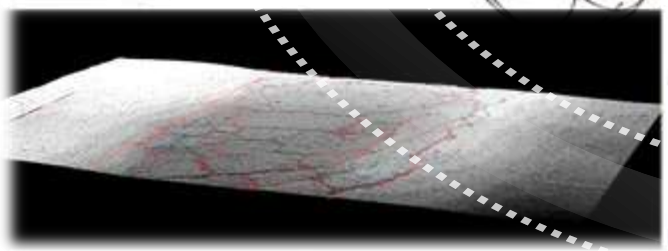
Maintenance Conditions of Each Bureau

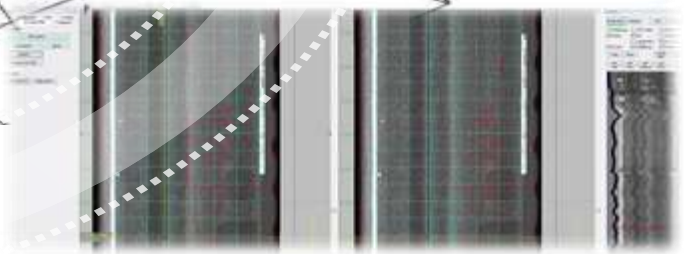


- Different bureau has different traffic volume and pavement conditions.
- Setting different curing threshold according to different bureau's condition

Conclusion and Suggestion







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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